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CONTENTS

	Page
Transport Policy in Great Britain	179
The Proteins Encompassed. By N. W. Pirie, F.R.S.	181
History of Technology. By Dr. Friedrich Klemm	182
A Policy for Wages. By Dr. N. S. Ross	183
Physics in One Volume. By Prof. G. O. Jones	184
Glossary of Coals. By Dr. J. Bronowski	184
The Ages and Origin of Meteorites. By Dr. P. Reasbeck and Dr. K. I. Mayne	186
A New Method for the Absolute Measurement of High Pressures. By R. S. Dadson	188
The Commonwealth Mycological Institute : Opening of New Building. By Dr. S. P. Wiltshire	189
Obituary : Dr. Bernard J. Flurscheim. By Prof. C. K. Ingold, F.R.S.	191
News and Views	191
British Food Manufacturing Industries Research Association : Open Day	196
Radiation Chemistry of Solutions. By M. Ebert and P. Howard-Flanders	197
Polarographic Instrumentation : First Symposium of the Polarographic Society. By Dr. A. L. Glenn	198
Library Resources in the Manchester Area. By A. R. Cameron	198
Radio Communication by Wave Scattering	199
Vegetation of the Assam Valley. By Prof. E. P. Stebbing	200
Relationship between Certain Components of the Cytochrome System. By Prof. D. Keilin, F.R.S., and Dr. E. F. Hartree	200
Letters to the Editors :	
Function of the Bower of Bower-birds.—Ellis McNamara	207
Aphid Chromosomes.—A. W. Colling	207
Regeneration of the Filtrable Forms of *Salmonella enteritidis* in Media containing Blood Plasma (Fibrin Structure).—I. Juhász and J. Vadász	208
Manganese Requirement and Carbon Source in *Chlorella*.—Prof. André Pirson and Ludwig Bergmann	209
Genetics of Endosperm.—Dr. A. Rutishauser	210
Influence of the Origin of the Isolate of *Rhizoctonia solani* on its Pathogenicity.—Dr. M. K. Tolba and A. H. Moubasher	211
Apparent Reciprocal Exchange of Characters between the *Mel* and *NWS* Strains of Influenza *A* Virus in the Brain of One-day Old Mice.—Dr. K. B. Fraser	212
A New Species of Sporozoan?—J. B. Cowey	213
Glacial Shore-lines.—Dr. P. B. McFarlane	213
Slow Disappearance of Fluorescence in Thionine on Addition of Abietic Acid.—Prof. Santi R. Palit and Byomkesh Biswas	214
Micro-determination of Phosphorus.—D. N. Rhodes	215
Infra-Red Spectra and the Polymorphism of Glycerides.—Dr. D. Chapman	216
Strain in 6,8-Thioctic Acid.—Dr. S. Sunner	217
Autoxidation of Catechin.—Dr. D. E. Hathway and J. W. T. Seakins	218
Occurrence of Different Beta-Lactoglobulins in Cow's Milk.—Dr. R. Aschaffenburg and J. Drewry	218
Action of Insulin on Thiamine Phosphorylation *in vitro*.—N. Siliprandi, V. Boffi and A. Lucarelli	219
Lumi- and Meta-Rhodopsin.—G. A. J. Pitt and M. Tinkham	220
X-Ray Emission Spectrography using Ion Exchange Membranes.—Dr. W. T. Grubb and Dr. P. D. Zemany	221
Radio-Frequency Radiation from the Rosette Nebula.—H. C. Ko and Prof. J. D. Kraus	221
Electron Micrographs from Thick Oxide Layers on Aluminium.—C. J. L. Booker, J. L. Wood and A. Walsh	222
Reactivity of Freshly Formed Steel Surfaces.—A. Prince	223
A Method of locating Interfaces in Oil Pipelines.—D. B. Smith and G. R. Church	223
Recent Scientific and Technical Books	Supp. vi

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TRANSPORT POLICY IN GREAT BRITAIN

IT is now more than two years since the Minister of Transport, then Mr. A. Lennox-Boyd, stated in the House of Commons that to delay an extended programme of major road improvements in Great Britain would cause serious damage to the economy of the country. At that time the total Exchequer expenditure on the schemes to be authorized in the next three financial years was not to exceed £50 million, and no major reconstruction schemes to forestall serious damage to our economy were contemplated. Within two years, however, the Government was forced, almost simultaneously with its plans for reconstructing railways, to formulate plans for expending £147 million, spread over four years, on roads, together with an average of about £117 million per annum.

The plans announced by Mr. J. A. Boyd-Carpenter on February 2 provided for new motor-ways from London to Yorkshire and from Preston to Birmingham, but at a date still unspecified. A start was to be made with a crossing of the Firth of Forth, though the decision between a concrete tube moored to its bed, estimated to cost £5·5 million, and a bridge costing £15 million had still to be made. A new high-level bridge over the Manchester Ship Canal was to be built as part of the Manchester outer ring road, and there were a number of subsidiary and very useful improvements to be made to existing roads; but there were some notable omissions, such as the Severn scheme and the Tamar bridge. It was also announced that the Government was prepared to consider charging tolls where appropriate.

There was no indication in Mr. Lennox-Boyd's statement that the Government is ready to tackle road reconstruction with the urgency that, on its own showing, is required, and the merits of the individual schemes do not suggest that reconstruction is being planned as a whole; rather it seems to be a series of piecemeal improvements. The plans made on paper give no sign of comprehensive policy, or that the old tradition that roads are a local responsibility is being combated. The Minister of Transport is still directly responsible for little more than eight thousand miles of road out of more than 180,000 on which public money is spent, and to more than half the total mileage of roads in Britain the central government contributes nothing. Road construction and efficiency thus depend largely on the enterprise and vision or indifference—and on the reluctance or willingness to spend local rates primarily to benefit through traffic—of nearly 1,300 local authorities.

Schemes for 340 miles of new motor roads which Mr. Lennox-Boyd's successor as Minister of Transport, Mr. Boyd-Carpenter, announced on July 5 as a first instalment of the Government's plans the day after the Road Traffic Bill had received its second reading in the House of Commons show, therefore, a welcome advance. Nevertheless, they scarcely measure up to the urgent need during the next two decades to spend more of the national income upon roads and such facilities as bridges, fly-overs, etc., designed to increase the efficiency of roads and their adequacy to the traffic they carry. Although it is expected that all the new motor roads will be completed within ten years, and that a start will be made on all within four, it will still be nearly ten before the major projects are complete. Inclusive of land purchase, they are expected to cost on average about £250,000 a mile. Including seven [illegible] totalling 84 miles and costing some £20 million, the total cost is estimated at £85 million, and by 1959 annual expenditure on roads will run at about £50 million a year.

The two motor-ways specifically described by Mr. Boyd-Carpenter are a first section of fifty-three miles of the London–Yorkshire motor way between St. Albans and Dunchurch, near Birmingham, and one of 94 miles between a point north of Birmingham and the Preston by-pass. The by-pass roads will be built to motor-way specifications, and the Ministry has endeavoured to incorporate the lessons of Continental and American experience. The London–Yorkshire motor-way will have six fly-over junctions, at four of which it will be joined by slip-roads to a roundabout built above or under the motor-way on the level of the existing road, and there will be no access to the motor-way except at these points. Parking will be prohibited except in lay-bys, and although it is expected that the acquisition of land and other preparatory work may take up to two years, thereafter the work should go ahead quickly. It is anticipated that the lines of the new roadways will be indicated precisely in September.

Mr. Boyd-Carpenter's statement indicates that the Government is drawing on the full range of technical experience of other countries as well as on the knowledge placed at its disposal by the work of the Building Research Station (Department of Scientific and Industrial Research). The timing of the programme, however, scarcely suggests that the Government is alive to the urgency of the task of matching what is largely an eighteenth-century road system to the needs of mid-twentieth century traffic, or to the speed of construction made possible by the recent great advances in the mechanization of road construction. The civil engineering industry has stated categorically that materials and skilled man-power for doubling the size of the present programme are available. Admittedly these resources cannot be deployed until the surveys involved and acquisition of the land required have been completed; but that is a further reason for planning on a larger scale, so that the full technical resources available can be put into operation immediately the more time-consuming operations of survey have been completed and legal problems settled.

That makes it the more imperative that the Government should now detail its plans for road construction and improvement as part of a national policy for roads, which itself forms part of an even larger policy for transport, taking full account not only of rail transport but also of the contribution

which other forms of transport such as canals and aviation, including helicopter services, could bring to the alleviation of congestion and use of the roads. The recent railway strike showed that there is still a good deal of traffic that could go by road rather than by rail, and that the fullest use was not yet being made of available road services, disregarding the congestion which retards their efficiency. It is no less true, however, that much heavy traffic goes by road which does not contribute in proportion to the damage it does to road surfaces, or the congestion it causes, and which from the national point of view should go by rail. Further, as was remarked in the House of Commons, the high cost of transport is already encouraging private transport instead of the use of public transport to an extent that increases congestion and makes the public service vehicles still less remunerative.

It is for such reasons that the plans announced by Mr. Boyd-Carpenter are disappointing, though they might have been more acceptable had they been presented as part of a comprehensive plan and accompanied by unmistakable evidence of a sense of urgency and of determination to grapple with the issues with imagination and energy. Much of the criticism of the Road Traffic Bill arises from a similar cause. As Mr. Boyd-Carpenter quite rightly said in concluding the debate on the second reading of the Bill on July 4, it is only intended to embody that part of a policy which requires a change of the law; but he gave little indication that the Government has thought out the comprehensive policy implied by his remarks.

The Road Traffic Bill embodies some good features which did not receive due recognition in the debate, notably in giving the Government power to start experiments in traffic control and in dealing with congestion. Essentially it is a measure designed to increase road safety and to reduce congestion, and in introducing the Bill, the Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, Mr. Hugh Molson, claimed that it rested on the three determinants of road safety stressed by the Departmental Committee—the application of technical or engineering skill, education and enforcement. It embodies indeed, as the Minister himself claimed, the major part of the Government's policy in respect of congestion and of road safety, and he made the important admission that the major road programme assumed that there would continue to be a very great expansion in the number of vehicles on the roads of Britain. By 1980 there will probably be four times the number of private motor-cars on the road than there were in 1939, and twice the present number.

Accordingly, it is the more important that bad, dangerous and incompetent driving should be penalized severely, because in the future dangerous driving will become an even grosser social evil than at present; it is from this point of view that the penal provisions of the Bill are a subsidiary part of a major road programme. As such, however, they appear to be open to two criticisms. The root difficulty with driving offences is the present uneven administration of the law. To remedy this may well be essentially a matter of public education; but the debate on July 4 indicated that the Government would receive plenty of support if withdrawal of a driving licence were made an automatic consequence in any conviction for dangerous driving. The second criticism relates to the renewal of provisional driving licences. Apart from the question of the number of competent examiners, some attempt should be made to check the repeated issue of provisional licences to holders who have not attempted to take the test. The sensible suggestion has been made that a second or third provisional licence should be made increasingly expensive for those who have not attempted to take the test when opportunity has been offered.

There are two other main points of criticism of the Road Traffic Bill which were freely expressed in the debate and to which no adequate answer was given by the Government. The first of these is in relation to parking. The use of parking meters may well be worth trying; but provision of adequate parking space off the streets is a matter of urgency which cannot be shelved, even if it involves a concomitant problem of bringing more traffic into the large towns. Mr. Ernest Davies commented in this connexion on the freer flow of traffic through London during the railway strike, which he attributed to three factors: the increased restriction on parking in Central London; manual direction of traffic by the police; and the acceptance by drivers of the necessity for these further regulations and their consequent co-operation with the police.

These matters obviously involve problems of public education and understanding, both of which are important factors in the second and more serious criticism made of the Bill. The Government has decided for the time being not to make the testing of vehicles compulsory in Great Britain. The proposals to that end embodied in the Bill introduced in the previous session admittedly had serious practical difficulties; but in a matter involving public safety to this extent, Mr. Molson's reason for dropping the proposal was inept. After establishing a convincing argument for compulsory tests he added that, although the Government believed inspection of vehicles would reduce the number of road accidents, if public opinion was not prepared to put up with the additional interference and inconvenience, it was unwise to try to legislate ahead of public opinion.

That is an abdication of public responsibility which ought not to be tolerated, and apart from the risks to life and limb involved, it deprives the public of the benefit which expert knowledge could contribute to road safety. It may well be that a system of inspection of all vehicles is at present impracticable; but a start could be made with the inspection of all vehicles of more than a specified age. In addition, the Government, on the evidence before it, should be undertaking a campaign of public education designed to secure full support for a more drastic policy at an early date, and it should also be seeking the means by which to implement that policy through the provision of appropriate inspectors.

Road policy has two main aspects, and these are not opposed as is sometimes implied. There is the

aspect of road safety, and there is the economic or productive aspect. Both are social, and neglect of either has anti-social as well as economic consequences. The country can ill afford the continued toll of life which defective vehicles and dangerous driving take week by week, and the Federation of British Industries and the Trades Union Congress agree that improved roads would be the biggest single contribution to higher productivity.

Road policy is, however, interlocked with transport policy generally, and with the larger question of the use of land and of urban as well as rural development, and there are implications for local government. That is why a series of piecemeal improvements or projects is regarded with distrust unless it is presented with clear evidence that the wider implications have been considered. As Mr. Strauss remarked, much traffic at present on the roads could go, and in the national interest should go, on the railways, and he also suggested that expenditure of £5 million upon canals might be more advantageous than a like or greater expenditure upon new roads. Mr. Strauss was undoubtedly right in urging that the possibility of making greater use of canals in future should be an essential part of any study for a comprehensive traffic policy, and the Government clearly must make up its mind what action to take on the report of Lord Rusholme's Board of Survey of Canals and Inland Waterways. Some policy for canals is essential and any such policy will involve expenditure; to neglect this on the excuse that we have already to face a plan for modernization of the railways will involve waste rather than saving of our resources.

Inland transport in Britain, it cannot be too strongly emphasized, must be considered as a whole and in relation to the implications not only of scientific advances in road construction, in electric transport, the diesel engine and the utilization of fuel, but also in relation to the rising costs of solid fuel, labour and the potentialities of nuclear energy. It is a problem to which the contribution of the scientist and technologist is indispensable; but it is also a problem with which the scientist and technologist are concerned as citizens as well as professionally. For that very reason they are the better equipped to participate in the task of public education which will be required as part of any comprehensive policy if success is to be achieved; and they should also be qualified to help to keep the discussion of the large issues involved objective and free from political prejudice. The Government's plans for road construction and for the modernization of railways and the Road Traffic Bill raise issues which concern many scientists professionally. But they also challenge all scientists to take part in the task of public education which the framing and execution of a transport policy embodying the full advantages of scientific advance demand; the administrative changes alone required for any adequate and effective system of supervision as well as planning of the road system of Britain as a whole are immense, and will not be acceptable unless they are understood and receive full support.

THE PROTEINS ENCOMPASSED

The Proteins

Chemistry, Biological Activity, and Methods. Edited by Hans Neurath and Kenneth Bailey. Vol. 2, Part B. Pp. ix+663–1418. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1954.) 16.50 dollars.

THE final volume of this four-volume work has now appeared, so that it is possible to consider balance and completeness of the whole. Different editors would probably have divided up the subject somewhat differently, and different types of protein might sometimes have been used as examples. But there are no glaring omissions. There may, however, be some inconsistencies; thus, nucleoproteins have a chapter to themselves, while mucoproteins and lipoproteins are dealt with incidentally and so have to be searched for in the index. A general survey of those proteins which are firmly attached to 5 per cent or more of material other than amino-acids would have been valuable, particularly if it had discussed the nature of the links between the peptide moiety and the prosthetic group.

There are six articles in the volume, each ninety or more pages long, and some of them would have made excellent monographs. The doubts about the usefulness of binding monographs together, already raised when reviewing the third volume (*Nature*, 174, 762; 1954), may be repeated. Some articles will get out of date much sooner than others, and separate publication of sections would make revision easy.

W. L. Hughes discusses the various functions that a circulating plasma might be expected to play and then considers, for each plasma fraction in turn, the evidence that it fills a specific role—for example, that it is a hormone or protection against an infective agent, or that it has a general nutritive or solvent function. Protection is considered in more detail in the chapter by W. C. Boyd on immune reactions. He gives a clear account of the diffuse fields of antigenic specificity and of the nature of the union between antigen and antibody. The final picture is as valid and comprehensive as could have been drawn in the space, though it contains a few irrelevant surprises: What, for example, is the evidence that "most plant proteins seem to be good antigens" or that protein synthesis goes on in viruses? Many would argue the contrary.

There are two articles on structure proteins: J. C. Kendrew on silk, keratin and collagen, and K. Bailey on muscle. In many other articles in these volumes the assumption is made, sometimes explicitly, that proteins with defined functions have unique structures and that heterogeneity in the preparations is a consequence of damage to the protein or of admixture with other proteins. It is pleasant, therefore, to find Kendrew emphasizing that homogeneity is a term with no relevance to insoluble proteins. Bailey starts his survey with Moses and Aristotle. The conclusions of more recent authorities on the interrelation of the actions of the various muscle enzymes are described lucidly, and stress is laid on the difficulties introduced into attempts at muscular micro-anatomy by the tendency myosin has to adsorb enzymes with which it may not have been associated *in vivo*. Both chapters make good use of the X-ray and electron microscope evidence that has been brought to bear recently on the problem.

N. M. Green and H. Neurath discuss proteolytic enzymes. They assemble a vast amount of evidence

about the kinetics of action of different enzymes on substrates of known structure. It is puzzling that out of this no positive suggestion has yet come about the nature of the active spot on a protease. There may already be abundant hieroglyphs on this Rosetta Stone but neither a Young nor a Champollion to read them! Two points now seem to be clear: there is only one active site on some enzymes, and the proteolytic site is also used when the enzyme catalyses transpeptidization.

The final article is the most ambitious. H. Tarver, discussing peptide and protein synthesis and protein turnover, arouses the reader's suspicions at the start by claiming objectivity. This presumably is what the other contributors to these volumes were aiming at, and they seem to have been no less successful in achieving it. However, the article gives a useful survey of a difficult field and comments shrewdly on the gap there often is between the interpretations that follow of necessity from a set of observations and the interpretations that are published. Tarver discusses the alternative possibilities—that proteins are in a state of flux with a regular 'turnover' or that they are stable in the environment in which they were synthesized. No positive conclusion can yet be reached; perhaps because in this respect, as in others, proteins are protean. N. W. Pirie

HISTORY OF TECHNOLOGY

A History of Technology

Edited by Charles Singer, E. J. Holmyard and A. R. Hall; assisted by E. Jaffe, R. H. G. Thomson and J. M. Donaldson. Vol. 1: From Early Times to Fall of Ancient Empires. Pp. lv+8 maps+828+36 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1954.) £7 7s. net.

THIS book presents the first of five volumes of a wide-ranging history of technology for which the English-speaking nations will be envied by others. The whole work will deal with the development of technology from the Stone Age down to the end of the nineteenth century. Its publication has been made possible by the help of Imperial Chemical Industries, Ltd., an organization which has shown its interest in the history of science and technology by publishing the very attractive and useful periodical *Endeavour*.

The very great amount of material for the present work has been divided up between a large number of well-known men of science, working under a triumvirate of editors, headed by that distinguished historian of science and medicine, Dr. Charles Singer, in whose honour his colleagues published two years ago a *Festschrift*, "Science, Medicine and History" (London, 1953), in two volumes. The second and third editors are E. J. Holmyard, the historian of chemistry, who was also the editor of *Endeavour*, and A. R. Hall, the historian of the natural sciences, well known also as the author of an excellent history of ballistics in the seventeenth century (Cambridge, 1952) and of a history of the scientific revolution, 1500–1800 (London, 1954). What is perhaps missing is the name of a historian of technology among the editors, but Dr. Singer's field of research is so wide that one can also reckon him in this category; one need only think of his masterly treatise on the history of the alum industry ("The Earliest Chemical Industry", London, 1948). Apart from this, the advice of a prominent British historian of technology, H. W. Dickinson, was sought during the planning of the five volumes, but unfortunately he died in 1952.

The work is not meant for historians of technology only, but rather as a contribution to a reader's general technical education. Its intention is to give to students and research workers in the field of technology and applied sciences the humanistic and historical background of their studies. It is designed to show them that the problems of their specialized studies have had a long history and have originated in different civilizations. The work will also be useful to history students in general by showing them the development of material culture.

The first volume covers the period from the palæolithic age to the downfall of the empires of the ancient East. Part 1 starts with a history of the fundamental social conditions of early humanity. K. P. Oakley deals with man as tool-maker, and V. Gordon Childe then discusses the early forms of society, in which he gives a good definition of the term 'technology'. H. S. Harrison describes how the early inventions were made, developed and spread. A. Sommerfelt deals with the problem of language, and R. E. Leach concludes Part 1 with an article about the primitive calendar.

Part 2 is devoted to the age of the hunter and hoarder. L. S. B. Leakey writes on the technology of stones, bones and wood, and, in another contribution, with palæolithic art. Daryll Forde describes the early ways of hunting and fishing. As to traps for animals (p. 177), mention might have been made to J. E. Lips's "The Origin of Things" (New York, 1946), in which book a very vivid description of those first machines of mankind is to be found.

Part 3 is devoted to domestic activities. Gordon Childe writes very instructively about rotary movement and the early history of the drill, the potter's wheel and the carriage wheel. In his bibliography (p. 214) he might have mentioned the instructive papers of H. T. Horwitz ("Die Entwicklung der Drehbewegung" in *Beiträge zur Geschichte der Technik*, **10**, 179; 1920) and of O. Mahr ("Zur Geschichte des Wagenrads" in *Technikgeschichte*, **23**, 51; 1934). H. S. Harrison introduces his readers to the early ways of firemaking and of using materials for heating and lighting. The picture (p. 217) on "The Domestication of Fire" from the Parisian edition of Vitruvius (1547) is only a free reproduction of the woodcut in the famous Vitruvius edition of 1521, published at Como. The pneumatic firelighter (p. 227) was no doubt only introduced to Borneo by the Portuguese in the nineteenth century, and can therefore not be said to be autochthonous. R. J. Forbes, who is well known through many of his papers as a historian of technology, writes about the technology of chemistry, cookery and cosmetics. The last article of Part 3, by J. Bradford, describes very vividly the different forms of structures which were made by using wood, woven reeds or turf.

Various technical activities are considered in Part 4. F. E. Zeuner deals with the domestication of animals and the cultivation of plants; to the bibliography, H. Nachtsheim's book, "Vom Wildtier zum Haustier" (second edition, Hamburg, 1949), might usefully be added. Sir Lindsay Scott tells the early history of pottery. In an excellent paper, G. M. Crowfoot deals with textiles, straw plaiting and mat-making. Two appendixes by J. Grant and K. R. Gilbert deal with the materials of ancient

textiles, basketry and rope-making. Then follow papers about bricks and stone structures (S. Lloyd), the Stonehenge monument (R. H. G. Thomson), the differentiation of non-metallic utensils (S. M. Cole) and the use of irrigation and agriculture (M. S. Drower).

Part 5 deals with the use of metals. Mines and quarries are dealt with by C. N. Bromhead. R. J. Forbes describes how metals were won from ores, and how they were melted and alloyed. H. H. Coghlan deals with utensils and metal weapons, H. Maryon and H. F. Plenderleith with fine metal-crafts, R. D. Barnett with objects made of ebony, and C. Aldred with artistic woodwork.

The subject of transport is the theme of Part 6. S. M. Cole describes wheeled vehicles and deals with roads and bridges. Wheeled vehicles are also described by Gordon Childe. The part is concluded by A. Digby's paper on boats and ships down to the type of the Ægean galley.

Part 7, the last one in the volume, considers things essential for the development of natural sciences: S. H. Hooke tells the history of writing, F. G. Skinner that of weights and measures, and O. Neugebauer that of mathematics and astronomy in the Ancient Orient.

The book is splendidly illustrated, most impressive being the thirty-six photographic plates. Some of the contributions have excellent bibliographies; but others have none at all—which is a pity. Each article should have its own bibliography; it is not enough to direct the reader's attention to R. J. Forbes's "Bibliographia Antiqua" (Leyden, 1940–50). It need scarcely be said that a standard work like this has a detailed index. Special features are the chronological tables by F. E. Zeuner covering the period from the geological ages down to the birth of Christ, and the chronological tables of prehistoric and historical civilizations of the Near East. In conclusion, I should like to say that the work succeeds in achieving its objects, as might be expected from the profound knowledge and truly humanistic outlook of its editors and contributors. We are waiting with impatience for the other volumes.

FRIEDRICH KLEMM

A POLICY FOR WAGES

The Social Foundations of Wage Policy

A Study of Contemporary British Wage and Salary Structure. By Barbara Wootton. Pp. 200. (London: George Allen and Unwin, Ltd., 1955.) 15*s*. net.

THERE is much in this book by Mrs. Barbara Wootton that is familiar to students of economics and industrial relations. The limitations of economic theory which seeks to explain the process of wage determination on the basis of a set of highly unrealistic assumptions have long been the cause of dissatisfaction both to economists and to those who look to theory as a possible source of guidance in practical affairs. Equally, the failure of theoretical analysis to account satisfactorily for what the author describes as curiosities of British wage structure—extreme inequality of rewards far beyond the range of individual differences in inborn aptitudes or in costs of training; the lack of an inverse relationship between the monetary and non-monetary attractions of different jobs, or of a positive relationship between the length of the normal working week and the standard time-rate of wages; variations in the practice of differentiating wage-rates according to sex—is a not unfamiliar theme, and much of the description and comment on methods of wage determination, on the attitudes and policies of trade unions, employers and arbitrators are inevitably part of the common stock-in-trade of all those whose professional or academic interests lie in the field of industrial relations.

Nevertheless, one of the great merits of Mrs. Wootton's work is her vivid and spirited presentation of familiar arguments, accompanied by penetrating observations based on a long academic and practical experience, to demonstrate once more that the economist's highly simplified account of the process of wage determination must be supplemented and modified by analysis of the institutional, social and ethical considerations surrounding the wage bargain. With this book, Mrs. Wootton joins the growing company of challengers, from Mr. J. W. F. Rowe in Britain to Mr. A. M. Ross in the United States, whose work may stimulate attempts to reformulate economic theory in this very significant area.

Analysis of these non-economic considerations is held to show the existence of two distinct and opposing sets of forces: ethical considerations—justice and fairness—are said to pull in the direction of equality; social considerations—status and prestige—make for conservatism and the maintenance of traditionally established differentials. In a wide survey of wage negotiation and arbitration in recent years, Mrs. Wootton concludes that, notwithstanding the tendency to phrase the arguments in ethical terms, the emphasis on the social factors of status and prestige has tended to produce an increasing degree of rigidity in the wages structure. Moreover, since conservatism justifies itself, no principles need be sought, and thus expediency or reference to custom becomes the rule.

This absence of principles of decision prevents the development of a coherent wage policy and stultifies the work of negotiators and arbitrators. So far as arbitration is concerned, the lack of principles has, of course, long been recognized as a major difficulty. Contrary to Mrs. Wootton's statement that, in the report of the 1954 court of inquiry in engineering, "the true nature of the problem here was explicitly stated at last", the difficulty was in fact recognized in the Report of the Royal Commission on Trade Unions of 1867–69, which rejected compulsory arbitration on the grounds that "there are no admitted principles of decision on which an arbitrator may proceed". For Mrs. Wootton, arbitration is a judicial process in spite of the absence of principles or of governmental statements of policy. In fact, however, it may be regarded as a legislative process, since the arbitrator is not being asked to interpret existing laws but to make a new law—a situation which led Parliament throughout the nineteenth century consistently to refuse to grant compulsory powers to arbitrators despite the widespread desire to strengthen the system of arbitration. Mrs. Wootton would not only require Parliament to legislate, in very broad terms, on wages policy, but also would expect negotiators and arbitrators to act as interpreters of this legislation. This proposal, quite apart from its merits, ignores the practical difficulties, which also beset the idea of compulsory arbitration, of enforcing the law against the very large groups of aggrieved workers which may emerge under certain conditions.

Finally, in addition to advocacy of guidance in wage policy by pronouncements of economic planning, the one principle suggested by Mrs. Wootton, that of equality, appears to spring from a particular set of social and political beliefs rather than from any practical consideration of the unquestionably urgent problems involved in the present wages situation in Great Britain.

N. S. Ross

PHYSICS IN ONE VOLUME

Textbook of Physics

Edited by R. Kronig, in collaboration with J. De Boer, H. C. Burger, P. H. Van Cittert, C. J. Gorter, A. C. S. Van Heel, P. Van Der Leeden and G. J. Sizoo, with biographical notes and tables by J. Korringa. (Translated from the Third Dutch Edition published in 1951.) Pp. xv+856. (London: Pergamon Press, Ltd.; New York: Interscience Publishers, Inc., 1954.) 70*s*. net.

A DISINCLINATION to believe that he has ever known more than could be put into one book has often persuaded the reviewer to hope for a single comprehensive text-book of physics which could be safely recommended to students and which could be used as an occasional refresher for himself—now happily beyond active service in examinations.

This English translation of a very successful text-book written by a group of Dutch physicists during the Second World War is probably the most ambitious attempt yet made at providing in one volume an account of physics as a whole at a reasonably advanced level. It would be easy to make criticisms of detail or complaints about particular omissions; but a more appropriate treatment—which this book deserves—would be to attempt to explain what it does and does not succeed in doing.

First, as would be guessed from the names of the contributors, the treatment is of high quality. Its level is roughly that which an honours student might aim to reach at the end of his second year; it would not be adequate for a third year in which any specialization was permitted. It is modern in outlook on the whole; for example, in discussing elasticity it mentions interatomic forces, but does not describe all the variations possible in the measurement of surface tension. It does not deal only with theoretical principles, but gets down to such practical details as the design of optical instruments. In general—though not everywhere—the phenomenological description is placed first; there are, for example, fifty pages on vibrations and waves early in the book. Unusual features include a section on medical physics and a collection of biographies of famous physicists.

However, the final and perhaps inevitable verdict must be that too much of the matter has been over-condensed. Perhaps two volumes really are necessary. To take a few examples at random: the cyclotron is dismissed in half a page, the Linde method of liquefying gases in two lines, infra-red spectroscopy in two separated paragraphs, piezo-electricity and ultrasonics in half a page. In the first chapter, in which an account is given of the objects and methods of physics, a discussion of errors is given which occupies only half a page, and an even shorter discussion of graphical methods. To be frank, one cannot imagine a student deriving much from such abbreviated accounts unless he is also pursuing a normal course of physics and has access to other books. In other words, this book must be regarded as additional reading. In this capacity it would be greatly stimulating to a serious student of physics. Within these limits, the book is about as good as one written by a group of authors could be, and probably better than one author could hope to write.

The diagrams are excellent, and the writing is free from eccentricities often found in translated work. The price, though high, is probably—in terms of pence per word—a good deal lower than the present-day average.

G. O. Jones

GLOSSARY OF COALS

Coals and Bitumens and Related Fossil Carbonaceous Substances

Nomenclature and Classification. By Dr. S. I. Tomkeieff. Pp. v+122. (London: Pergamon Press, Ltd., 1954.) 17*s*. 6*d*. net.

A GLOSSARY of this wide and unsystematic subject has long been needed, and yet has never been made; it is admirable to have it now. Dr. S. I. Tomkeieff's book contains some thirteen hundred terms, of which all but about two hundred relate to coal. The body of the book lists these alphabetically, with short definitions and references. This is followed by a series of synoptic tables and some diagrams, which give schematic order to the bewildering variety of names and substances. The methods of these classifications are explained in a short introduction.

Dr. Tomkeieff has done his work well. Where so much of the matter is traditional and local, gaps can of course be found, and there are some oddities of usage. But the book is a remarkable collection across a multitude of dialects and even languages—there are nearly two hundred terms in some twenty foreign languages.

The interests of the author are those of the geologist rather than, say, the coal chemist, and in this respect the book falls short of the needs of the latter. For example, such important technical terms as 'volatile content' and 'carbon ratio' are defined in ways which are no longer the best standard practice. There is no classification of coals by the parameter of their ranks; and, most serious, the important modern work on the physical and chemical structure of coals is not mentioned. Outstanding progress has been made during the past few years in understanding the properties of different coals, by deductions made from their examination by X-ray, infra-red, and other physical methods. These researches offer the best promise for bringing order of a fundamental kind into the present empirical classifications; and the neglect of such ideas in this book is therefore regrettable.

The next edition would be greatly strengthened by including in the introduction a systematic account of modern physical and chemical theories of coal structure, and by adding to the synoptic tables and diagrams a classification based on them. In its present form, Dr. Tomkeieff's book is thoroughly useful; with these additions, it would become indispensable to all students of coal and allied substances.

J. Bronowski

l'Analyse Spectrale Quantitative par la Flamme

1—Propriétés de la Flamme : Réalisation et Utilisation. 2—Analyse des Émissions dans la Flamme. Par Dr. R. Mavrodineanu et H. Boiteux. (Publication de l'Office de la Recherche Scientifique Outre-Mer.) Pp. vi+248+11 plates. (Paris : Masson et Cie., 1954.) Broché 3,800 francs ; Cartonné 4,300 francs.

IN this volume, an excellent account is given of the theoretical and practical aspects of flame photometry. The book is divided into two parts, the first dealing with the general properties of flame sources and a very comprehensive consideration of the factors affecting the design of burners, atomizers and other components in a complete flame photometer. There are chapters on photoelectric and photographic methods, and also on instruments with dispersing systems and with filters. A short account is given of the interferences between different elements.

It is easy to suggest additional material which might have been included in any book, but perhaps a fuller account could have been given of the large amount of work done in recent years on photoelectric instruments, and reference made to the value of interference filters. The effect on flame temperature of the introduction of different salts also deserves attention, as one cause of interference between one element and another.

The second part of the book is concerned with the theory of the emission spectra of the flame itself and of the elements and compounds giving lines used for analysis. Its value lies in the inclusion within a single volume, not only of the spectral terms and energy-levels of a great many elements, but also of a full account of the molecular spectra of interest and the chemical reactions and equilibria within the flame. A list of useful spectral lines, and photographs of a number of flame spectra are included. There is an extensive bibliography of more than five hundred references, and a good index. The book makes a distinct contribution to a subject which has not recently been presented in a form primarily intended for the analyst.

J. R. STANSFIELD

Geology of Petroleum

By A. I. Levorsen. (A Series of Geology Texts.) Pp. x+703. (San Francisco : W. H. Freeman and Company ; London : Bailey Bros. and Swinfen, Ltd., 1954.) 8 dollars ; 68*s*.

GEOLOGIES of petroleum have in the past tended to a pattern of theory first, and practice second. In such works the principles are enunciated, explained, diagrammatically presented, and thereafter followed usually with geographically arranged oilfield stratigraphies and structures. Sometimes descriptive matter is too detailed, and a monotonous record of past developments is given ; these date quickly unless particularly exemplary. However, the author of this present book is fully aware that there is no point in cataloguing producing pools except as they illustrate specific principles that apply to exploration, for our first interest is in finding new producing areas, and this point of view is much to be commended.

Unrelieved oil geology, without full leavening of contacts with closely allied sister sciences, lacks inspiration and reality. Recognizing this, the author treats his material objectively : first the reservoir (emphasis on trap rock) ; then reservoir conditions (temperature, pressure, differential fluids) ; next "speculative ideas on origin, migration and accumulation" (the operative word here is 'speculative') ; and finally, "ways of applying what has been considered in the search for new pools and provinces". There is logic in this sequence. Geological manuscripts are inevitably read in terms of economic values, and theories put to practical trial by drilling. The experienced oil geologist can interpret his findings understandably to geophysicists, reservoir and production engineers and the like ; and this applies to administrative 'laymen' as well. Reciprocally, many of these other people desire to learn from a not too technical, modern text something of the geologist's technique. This is the book for them ; its appeal should be deservedly wide.

H. B. MILNER

Entire Functions

By Ralph Philip Boas, Jr. (Pure and Applied Mathematics : a Series of Monographs and Textbooks.) Pp. xi+276. (New York : Academic Press, Inc. ; London : Academic Books, Ltd., 1954.) 6 dollars.

THIS book presents in orderly fashion a wealth of material not previously brought under one cover. It is about functions of exponential type, with emphasis on entire (integral) functions. There are chapters on entire functions of finite order, the minimum modulus and functions with real negative zeros. Then follows a chapter on general properties of functions of exponential type, and then three chapters on special properties, such as the connexion between growth and the distribution of zeros. There is a chapter on uniqueness theorems, and this is followed by a chapter on growth theorems and one on operators and their extremal properties. The last chapter, on applications, is exciting because it demonstrates the wide field within which entire functions find a place. Illustrations are given of applications to Fourier series, power series on the circle of convergence, Dirichlet series and gap theorems. There are brief sections on differential equations of infinite order and approximation. It is a pity that these are so short ; but there is an extensive bibliography for those requiring more detail.

A survey of the present book shows that the subject-matter of the theory of entire functions consists of a great number of more-or-less special results. The indications are that these are becoming overwhelming in their numbers and ramifications. One is led to ask the question whether some general theory might be developed which will compress a lot of the known results into several strong channels. It certainly looks as if some new method of classification is needed. It may be that modern algebra and topology can help here, via such tools as ultrafilters and the structure theory of complete local rings, as used recently by Henriksen and others.

L. S. GODDARD

Physics for Medical Students

By Dr. J. S. Rogers. Third edition, revised and enlarged. Pp. xiii+405. (Melbourne : Melbourne University Press ; London : Cambridge University Press, 1953.) 35*s*. net.

FOR some twenty years Dr. J. S. Rogers's book has done admirable service in providing a course which supplements the ordinary university physics text, with applications of special interest to medical students. In this, the third edition, developments of nuclear physics and electronics are included, together with topics such as reflecting objectives and phase-contrast microscopy. Outstanding in its own field, the book will be gladly welcomed in this new edition.

G. R. NOAKES

THE AGES AND ORIGIN OF METEORITES

By Dr. P. REASBECK*
Londonderry Laboratory for Radiochemistry, University of Durham
AND
Dr. K. I. MAYNE
Clarendon Laboratory, University of Oxford

THE geological ages of meteorites have been discussed recently by several authors[1-3]. Paneth's classical helium method based on analyses for helium, uranium and thorium, now taking into account the helium generated also by cosmic rays[4,5], is being supplemented by the argon–potassium method[6-8]. The latter is, of course, only applicable to the stony phase of meteorites, since the iron phase contains too little potassium. It is clearly of interest to compare the apparent ages derived from both experimental methods. Two questions may now be posed: First, is there agreement in the ages found by both methods applied to identical samples of meteoric stone? Secondly, do either of these ages agree with that found by the helium method applied to meteoric iron? If the answer to the first question is in the affirmative, one can have much more confidence in the derived ages than one would have by either method alone. Granted this agreement, the answer to the second question cannot then fail to be significant in a discussion of the life-history of these bodies.

In the case of stone meteorites, very few age determinations have been made by the helium method, since some terrestrial minerals have been shown to be not necessarily helium-tight (see, for example, ref. 9), and it was thus assumed that the diffusive loss of helium from stone meteorites would invalidate the method. Evidence is presented here which indicates that this effect may not be so serious as presumed. It has been suggested[8] that diffusive loss of argon from stony meteorites should not, however, be large, and for this reason it seems of especial interest to compare results obtained by the two methods.

We have extracted the helium from meteorite samples and measured the amount and helium-3 content by gas analytical techniques described elsewhere[10,11]. Very careful blank assays showed that the amount of helium contamination from the atmosphere could be reduced, in the case of irons, to 0·1 per cent of the meteoric helium measured, and, in the case of stones, to a negligible amount. Determinations of the uranium, thorium and potassium contents of two meteorites were carried out on aliquot portions of the same samples, from which portions were taken for the helium and argon measurements.

In Table 1 are given the results of these determinations, and in Table 2 are collected the apparent ages of the two phases.

Other workers, using the argon–potassium method for stone meteorites, have reported figures similar to those given in Table 2. Thus, Wasserberg and Hayden[7] report $4{\cdot}6 \times 10^9$ yr. for Forest City and $4{\cdot}8 \times 10^9$ yr. for Beardsley; Gerling and Pavlova[8] give 3×10^9 yr. to $0{\cdot}5 \times 10^9$ yr. for some chondrites.

It may be noted that our figures for the helium method may be slightly in error owing to the presence of cosmogenic helium in addition to the radiogenic helium. A correction has been made in the case of Akaba and Brenham Township based on their measured content of helium-3. The ratio of helium-4 to helium-3 formed by cosmic rays in stony materials is not yet known, and, in any event, this ratio will vary with depth within the meteorite. A value of unity has been assumed in making the correction to the observed content of helium-4. This is unlikely to be far out, and even if the true ratio were as high as 3, the ages quoted would have to be reduced by less than 25 per cent.

It has always hitherto been considered that the helium method would probably not be reliable for stony meteorites, because of the risk of loss of helium by diffusion. A consideration of the figures in Table 2 indicates on the contrary that the loss of helium may not be very serious. Thus the observed deviation between the two figures in the case of the Akaba meteorite is in fact within the statistical error of the experiment, although it may be that in the case of Brenham Township meteorite about half the radiogenic helium has been lost. In addition, the lowest age found for a stone by the helium method is well within the range of ages found for stone meteorites by the argon method.

Table 1

Meteorite	Helium content (in 10^{-6} c.c./gm.)	$^3He/^4He$ ratio (%)	Uranium (in 10^{-6} gm./gm.)	Thorium (in 10^{-6} gm./gm.)
Beddgelert				
Stone	30	—	$10{\cdot}8 \pm 2{\cdot}7$	39 ± 8
Iron	2·8	—	$9{\cdot}1 \pm 1$	$8{\cdot}5 \pm 4{\cdot}9$
Akabar				
Stone	14·2	6·3	$0{\cdot}84 \pm 0{\cdot}08$ (J. C. Dalton, private communication)	$6{\cdot}0 \pm 2{\cdot}1$
Iron	Proportion of iron present in meteorite too small to permit determination			
Brenham Township				
Stone	3·44	1·0	$0{\cdot}69 \pm 0{\cdot}17$	$5{\cdot}3 \pm 2{\cdot}4$ (J. C. Dalton, private communication)
Iron	0·018	Helium content too low for mass-spectrometric determination	$0{\cdot}06 \pm 0{\cdot}02$	$< 0{\cdot}7$

* Now at the Physics Department, University of Birmingham.

Table 2

Meteorite	Helium method age	Argon–potassium age (ref. 8)
Apparent Ages of Stone Phase of Meteorites		
Akaba	$3{\cdot}2 \times 10^9$ yr.	$3{\cdot}6 \times 10^9$ yr.
Brenham Township	$1{\cdot}4 \times 10^9$ yr.	$3{\cdot}3 \times 10^9$ yr.
Beddgelert	$1{\cdot}2 \times 10^9$ yr.	—
Monze	—	$1{\cdot}8 \times 10^9$ yr.
Apparent Ages of Iron Phase of Meteorites		
Beddgelert	2×10^8 yr.	—
Brenham Township	4×10^8 yr.	—

It therefore does appear that the two methods are in substantial agreement, and that (having regard to the tendency for the helium method to err on the side of under-estimation) the true ages of stony-phase meteorites are of the order of $2\text{–}4 \times 10^9$ yr. They are thus of about the same age as the Earth and certainly not older than the revised expansion-age of the universe.

Our earlier figures for iron meteorites[4,10] have been criticized[3] on the grounds of giving too low an age. For this type of meteorite we had suggested an age of about 2 or 3×10^8 yr. However, it is now obvious that, by one and the same method, the age of the stone phase of the meteorites described here agrees well with the age derived by the argon method, while the iron phase is undoubtedly younger, and has an age in good agreement with our figure mentioned above for irons.

It has been argued by Urey[3] that on thermodynamic grounds it is unlikely for the observed uranium and thorium contents of meteoric irons to be correct. He suggests instead that the uranium and thorium are in fact held in small stone or sulphide inclusions within the iron, and that the ages are falsified by escape of helium along fissures in the iron. Such a loss of helium from the bulk iron would, however, seem extremely improbable, from the following experimental observations. (*a*) There is great difficulty in abstracting the helium from meteoric iron *in vacuo*, even at high temperatures[12]. (*b*) Further, no fall in helium concentration with approach to the surface is observed radially in meteorites[10], and, in fact, in the only meteorite large enough for the purpose so far available the measured concentration gradient was in the opposite sense to that which would be caused by diffusive loss of helium. (*c*) Several determinations have been made by one of us (P. R.) on each of twenty different iron meteorites; samples up to 20 gm. in weight were dissolved in dilute sulphuric acid, and in only one case (Toluca (Durham), 3·7 per cent of stone by weight) was any trace of stone observed after the iron had completely dissolved. This indicated that many iron meteorites have few or no stone inclusions at all, and that the uranium and thorium, and hence the helium, cannot then be postulated to come from such inclusions, since, where present, they would have to contain a far higher concentration of uranium and thorium than occurs in the bulk stony phase. (*d*) Even with the much more friable stone meteorites, we now have evidence that helium loss is small during what appears to be a much longer life-history. (*e*) No sign of such inclusions, which, as pointed out above, would have to contain a high concentration of uranium and thorium, have been detected by autoradiographs of meteoric iron slices. Thus, it seems that the only possible explanation of Urey's thermodynamic argument is that the true thermodynamic equilibrium, as regards the distribution of uranium and thorium between the two phases, was never achieved.

There remains always the possibility of experimental error. The uranium and thorium contents of the iron phase are about ten times smaller than those of the stone. It is therefore true that a systematic error in the measurements on the stone phase might not be noticeable, whereas the same absolute error in measurements of the iron phase would be quite important. Even so, it seems that the error in the case of the iron would not be as much as a factor of 2, whereas a factor of 10 would be required to explain the difference in ages. This consideration is quite independent of arguments based on the carrying out of duplicate analyses, blank analyses, and analyses by quite different methods, all of which have been done in the attempt to eliminate systematic errors. Further, the fact that the uranium and thorium figures for the stone phase give an age in agreement with that found by the argon method is an added indication of the validity of these figures, and hence, a confirmation of the validity of the uranium and thorium contents of the iron phase, which were measured by the same methods and under the same conditions as those of the stone phase[13].

At this stage it would be as well to correct the impression given by Urey[3] that we have suggested that all iron meteorites have lost much of their helium by being heated relatively recently in a close approach to the Sun. Such an event has indeed been postulated[5] to cover the case of three meteorites of very exceptionally low helium content; but it has never been suggested for the large majority of them.

The only other experimental approach to the ages of meteorites is that of Patterson and Hayden[14], who have investigated the isotopic composition of meteoric lead, and find evidence for an age of the order of $4{\cdot}5 \times 10^9$ yr. for stones.

In sum, it appears to be an inescapable conclusion that the stony phase reached an evolutionary stage, after which it has lost little radiogenic or cosmogenic gas, at a period about ten times as remote from us as the corresponding period for the iron phase. If this be accepted, the hypothesis of a planetary origin for all the meteorites seems attractive, the planet having undergone a cataclysmic break-up fairly soon after the solidification of the bulk of the iron phase[15].

This would offer an explanation for the existence of (*a*) old stone-phase meteorites; (*b*) younger iron-phase meteorites which are still old enough to have been exposed to cosmic rays for sufficient time to build up their observed cosmogenic helium, and which have cooled sufficiently slowly to form their Widmannstätten figures; (*c*) chondrites, pallasites, etc., which combine the features of (*a*) and (*b*). The suggestion of pallasite formation put forward by Lord Rayleigh (1944) may well be in agreement with the results presented here, as may also be the recent suggestions of Kuiper[16], that the melting of the metallic iron in the meteorites occurred late in the history of the solar system, the melting having been produced by radioactive heating in bodies that were highly insulated. The metallurgical investigations of Uhlig[17] also seem to present evidence for the irons having been formed in the interior of a large body.

It would now seem that the range of ages suggested for stony meteoric material, from about $4{\cdot}5 \times 10^9$ yr. by Wasserberg and Hayden down to about $0{\cdot}5 \times 10^9$ yr. for the 'youngest' meteorite

examined by Gerling and Pavlova, within which the present results fall, is not in serious disagreement with the range of ages for different terrestrial materials, while the younger age of meteoric irons can well fit into a general scheme of planetary evolution.

We wish to thank Prof. F. A. Paneth for providing the samples of meteorites, and for his continued interest in the work. [May 11

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A NEW METHOD FOR THE ABSOLUTE MEASUREMENT OF HIGH PRESSURES

By R. S. DADSON

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As part of a programme of work in the field of high-pressure physics, the National Physical Laboratory is now working on a project for the establishment of standards for the measurement of high pressures.

In practice, most measurements of high pressures intended to be of the greatest precision are made with pressure balances, or dead-weight gauges, of the familiar type in which fluid pressure acting on a piston of known area is balanced by a load applied by means of calibrated weights. The accuracy of such balances has hitherto been limited principally by the fact that at high pressures the piston and the cylinder in which it moves are distorted to an extent which is not easily measurable. As a result of this, the 'effective area' of the assembly is subject to an uncertainty which is likely to increase as the pressure is raised.

The usual method adopted in the past for the determination of the effective areas of piston–cylinder assemblies[1] has relied on the use of high-pressure mercury columns, but the results of these investigations have not so far given any clear or consistent indication of the changes in effective area under the influence of elevated pressures. A new standard mercury column of this type capable of operating up to about 2,500 atmospheres has recently been described by Bett, Hayes and Newitt[2], who discuss in detail a number of factors affecting the accuracy likely to be achieved. So far, however, no results of measurements with this instrument on actual balances have been published. While it is clear that a well-designed high-pressure mercury column is capable of the establishment of high pressures with considerable accuracy, it nevertheless seems likely to be a somewhat difficult instrument to use, mainly on account of the long and laborious series of pressure transfers which need to be made to reach the high-pressure range.

The purpose of this communication is to give a preliminary description of a new method for establishing the calibrations of pressure balances which has recently been developed at the National Physical Laboratory. In measuring the change of effective area of a balance as the pressure is raised, the method makes use of a quite simple principle of similarity as applied to pressure balances of the same dimensions but constructed of different materials. If we consider two piston–cylinder assemblies of the same nominal dimensions but of materials the elastic constants of which differ in a known ratio, then in certain circumstances, considered in more detail below, the distortions, under applied pressure, of the two assemblies will remain proportional to one another throughout the range of pressure concerned. Under these conditions, and neglecting small quantities of the second order, we may represent the effective areas A and B of the two assemblies at a given pressure in the form

$$A = A_0\{1 + \alpha.f(P)\}\,;\quad B = B_0\{1 + \beta.f(P)\}.$$

In these expressions A_0 and B_0 are the (nominally equal) effective areas at zero pressure, α and β are constants inversely proportional to the elastic moduli of the two materials, and $f(P)$ is an unknown function of the pressure, P. The ratio of the two effective areas will be given, to the same order, by the expression

$$A/B = A_0/B_0\{1 + (\alpha - \beta).f(P)\}.$$

This ratio is easily determined by balancing the two assemblies directly against one another, and this procedure determines the quantity $(\alpha - \beta).f(P)$. The quantity α/β may be obtained from direct measurements of the elastic constants of the two materials. These two procedures thus enable the absolute value of the change of effective area of each of the piston–cylinder assemblies to be determined.

For the theory outlined above to be valid, a number of conditions must be satisfied, both as regards the materials and the construction of the assemblies. Since two independent elastic moduli will be involved in a somewhat complicated manner in the distortion of each assembly, true proportionality can only be achieved if both moduli are in the same ratio—in other words, the values of Poisson's ratio for the two materials should be closely similar. As regards construction, the forms of the internal bores of the cylinders, and of the pistons, must be closely similar in contour, since otherwise the distributions of pressure in the gap between piston and cylinder will not be the same in the two assemblies. The similarity principle also requires that the gap-widths at zero pressure should be inversely proportional to the elastic moduli. If these conditions are adequately met, and the elastic properties of the materials are uniform throughout the range of stress involved, proportionality of the distortions will be assured. This will remain valid even if the viscosity of the transmitting fluid is dependent on pressure, as will almost certainly be the case. It is, however, worth noting that the effective area of a pressure

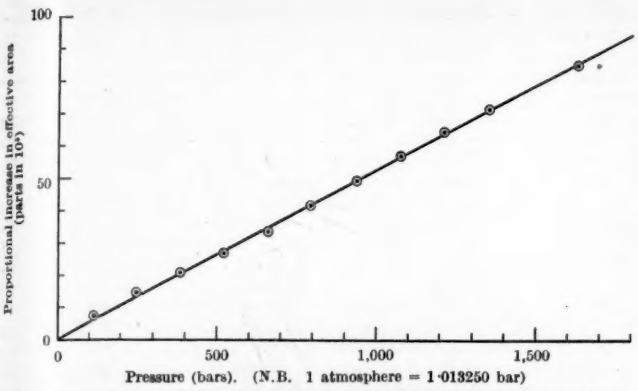

Fig. 1. Dependence of effective area on pressure for steel piston–cylinder assembly of nominal area 0·02 sq. in.

balance may depend to some extent, at high pressures, on the viscous properties of the fluid used.

The present series of experiments at the National Physical Laboratory is intended to cover the range up to 3,000 atmospheres. The two materials so far used are a hard tool steel and a special type of bronze of high tensile strength. The strains of the materials loaded in tension, compression and shear have been measured over the range of stresses imposed in the pressure experiments. Within the limits of accuracy of these measurements, the stress–strain relationships were linear and conformed to a fixed ratio of the elastic moduli of 1·44 : 1. Measurements in three directions at right angles which were made by the ultrasonic-wave velocity method, using longitudinal and shear waves, indicated the materials to be satisfactorily isotropic. The accuracy of construction of the assemblies is largely limited by the accuracy with which the cylinder bore can be made and measured. Owing to recent improvements which have been made in the Metrology Division of the Laboratory in the measurement of the form and diameters of cylinder bores[3], it has proved possible to construct piston–cylinder assemblies to the requisite precision, and with the required degree of similarity.

The results of the present series of measurements show that the method is capable of a very satisfactory degree of accuracy and consistency, and permits the measurement of the variation in effective area over a wide range of pressure to within a few parts in 10^5 of the total area. In fact, over small ranges of pressure, variations in effective area of only a few parts in 10^6 of the total area can be determined. An example of the results obtained is shown in Fig. 1, where it will be seen that a particular steel piston–cylinder assembly of nominal area 0·02 sq. in. may change in effective area by an amount of the order 1 part in 2,000 per 1,000 bars of applied pressure. In this instance the change proved to be a linear function of pressure to the order $\pm$ 1 part in 10^5 of the total area.

While the present series of tests is intended to cover the range up to 3,000 atmospheres, plans are being made to extend this range to higher pressures so far as may be practicable, and some further interesting possibilities of the similarity method are under investigation. Full details of this work will be published in a further paper. From the nature of the method it seems that it should be applicable over virtually any range over which pressure balances can be used, and in which two materials having the necessary properties are available. The main difficulty in the method resides in the construction of the highly accurate pistons and cylinders which are required. Once these are available, the experimental work in determining the variation of effective area is simple, quick and convenient.

We have so far dealt only with the variation in effective area with pressure, but at some point of the scale the effective area must be measured in absolute terms. This link is most easily made at a low pressure where distortion is known to be negligible. The present procedure at the National Physical Laboratory is to use two independent methods to obtain this measurement: (*a*) direct measurement by balancing at a low pressure against a mercury manometer; (*b*) by computing the effective area from the measured dimensions of the piston and cylinder.

These two methods of measurement have given agreement to within 2 parts in 10^5; but it is thought that this accuracy can be somewhat improved.

I acknowledge the helpful co-operation of the Metrology Division of the Laboratory, which undertook the measurement and construction of the special piston–cylinder assemblies required, and of the Engineering Section of the Physics Division, which determined the elastic constants of the materials.

The work described was carried out as part of the research programme of the National Physical Laboratory, and this communication is published by permission of the Director of the Laboratory.

[May 19

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THE COMMONWEALTH MYCOLOGICAL INSTITUTE

By Dr. S. P. WILTSHIRE
Director

THE opening of the new building of the Commonwealth Mycological Institute at Kew by H.R.H. the Duke of Edinburgh on July 13 was a notable event in the history of the Institute. Founded in 1921, the Institute first occupied two houses, 17–19 Kew Green, but in 1930 moved to a building in Ferry Lane, erected with the help of the Empire Marketing Board. That building rapidly proved inadequate and plans were prepared for an extension of it to be put before the Commonwealth Mycological Conference arranged for September 1939, but which had to be abandoned owing to the outbreak of war. Since 1939 the work of the Institute has increased enormously, and the Fourth Commonwealth Mycological Conference, held in 1948, recommended the immediate erection of a new building. The freehold

site on which the new building stands became available and was purchased in 1950 through the prompt action of the chairman of the Executive Council. Detailed plans were put before the Commonwealth Agricultural Bureaux Review Conference in 1950 and approved; but the cost was to be borne on a separate vote. Administrative difficulties arose and the funds for the building were not sanctioned until 1953. Building operations started in May 1954, and were just completed in time for the opening. The lack of accommodation has been most seriously felt; but the new building now erected to the plans of Messrs. Waterhouse and Ripley affords adequate and most suitable quarters.

The need for additional space may be judged from the fact that the staff of the Institute now numbers thirty-seven and includes ten mycologists covering the editorial and identification services, including the culture collection, six abstractors, five of whom are linguists covering most of the languages in the literature of the subject, a herbarium recording staff of three, an indexer-librarian and five technical assistants, besides clerical staff. In addition, there is a pool of three plant pathologists attached to the Institute by arrangement with the Colonial Office, which provides the necessary finance. These plant pathologists undertake research into the cause and control of disease in the Colonial dependencies when required and may be moved to danger spots at short notice.

In his address, the Duke of Edinburgh stressed the importance of plant disease control in increasing and maintaining agricultural production. The spear-head of the attack on plant disease is, he emphasized, research, and the fight is seldom once and for all. New diseases or new variations of old diseases are always cropping up. Plant diseases could have disastrous effects not only on the economy but also on the social pattern of a country. The Institute has the important task of making it easier for research workers to follow what is going on elsewhere and to avoid duplication of effort. Much is heard, he said, of the invisible links of the Commonwealth, but this is one of the tangible ones. He was glad to find it possible for Commonwealth countries to co-operate in this particular field, and he hoped everyone who works at the Institute would find it a rewarding occupation.

The building is in the Georgian style to fit in with the surrounding architecture. The ground floor is devoted wholly to the library, apart from a small room for the Director. The literature of plant pathology and mycology increased enormously during the Second World War, and as one of the main functions of the Institute is to abstract this information for its journal, the *Review of Applied Mycology*, adequate library accommodation is absolutely vital for its work. The opening ceremony took place in this spacious room, which in due course is to be fitted with the requisite shelving and furniture. The room is well lit by fifteen windows, and tables are to be provided for fifteen readers. For several years the purchase of journals has had to be limited from lack of space, and the need for reprints of plant-pathological and mycological articles published in past as well as recent years, especially from foreign countries, is very great. The library of the Institute should be one of the best phytopathological and mycological libraries in the world, and the co-operation of all plant pathologists is earnestly sought in supplying or making available the necessary literature. The collection of 'separates', now numbering some sixty thousand pamphlets, is to be incorporated in the library.

Besides the *Review of Applied Mycology*, the Institute publishes distribution maps of plant diseases, the "Index of Fungi", listing all new species of fungi described throughout the world, the *Review of Medical and Veterinary Mycology*, surveying the world's literature on this subject, *Mycological Papers*, recording the results of research in systematic mycology, and the quarterly *Commonwealth Phytopathological News*. The Institute has also issued several books, the best known being the "Dictionary of Fungi", by G. C. Ainsworth and G. R. Bisby.

The first floor of the new building accommodates the herbarium of the Institute, which now contains about 65,000 collections. The identification service, maintained for the benefit of Commonwealth plant pathologists and mycologists, is the other major activity of the Institute. From the start, the Institute has recognized that investigations into the etiology of plant diseases can only be made by plant pathologists working in the countries where the diseases occur; and on the other hand, the identification of the pathogens can only be carried out by trained systematists working in a herbarium with adequate literature and specimens available. The identification of fungi is difficult work and requires special qualities and prolonged training. Mr. E. W. Mason, chief mycologist, has developed a herbarium technique which is both unique and valuable and has built up an enthusiastic staff for this arduous task. For years the staff employed in the work have been greatly hampered by overcrowded conditions. In the new building, the main herbarium runs the whole length of the building, with the exception of a room for the chief mycologist. Rooms are also provided on the south side for herbarium records, a drying room where specimens can be dried for the herbarium, a culture room, and a disinfestation room where all incoming material is disinfested from beetles and other insects with methyl bromide. Fluorescent lighting enables the herbarium cases to be placed in rows, with a resultant great saving of space.

The top floor comprises four rooms for visitors, with eight working benches, and two large rooms for the culture collection, one a preparation room, and the main laboratory occupying the whole of the far end of the building. The collection now comprises upwards of two thousand cultures and is constantly being added to. Adequate storage cabinets designed for the work, incubators, cupboards, desks and benches make the laboratory a well-equipped and pleasant room for culture work. Special cabinets for making transfers have not been found necessary and are not incorporated in the new laboratory, with a corresponding saving in cost.

The basement runs the whole length of the building and provides accommodation for photographic dark-rooms, comprising two developing rooms, one studio and one microfilm room, storage room for publications, the boiler with space provided for a second boiler should the building ever be extended, a workshop, and a room for electric and gas meters. The building is constructed of reinforced concrete with hot-water pipes embedded in the floors, thermostatic control and automatic firing of the boiler, and provision for the mechanical delivery of the fuel from suitably constructed lorries. The plans provide for an extension of the building to double its present

size should this be required, and the internal walls can readily be removed without damage to the structure if a rearrangement of the rooms should prove desirable in the years to come.

The old building is being retained to house the administration and editorial and abstracting staffs, and one room is set apart for the pool of plant pathologists when they happen to be working in Great Britain.

OBITUARY

Dr. Bernard J. Flurscheim

Dr. Bernard J. Flurscheim, who died recently at his home in Fleet, was in his eighty-first year. So passes the last of the great pre-electronic builders of the theory of organic chemistry.

After a school education on classical lines at Baden and Bournemouth, Flurscheim made his first scientific studies in the University of Geneva; afterwards he worked with Werner in Zurich, and with Thiele in Strassburg. He took his Ph.D. degree in Heidelberg in 1901. In 1905 he set up his house in Fleet, in the garden of which he built the laboratory, where he worked, until other duties claimed him in the First World War. For the periods 1905–7 and 1925–28 he worked in the Royal Institution in London.

In his main scientific work, the provision of organic chemistry with a theoretical framework, Flurscheim was natural successor to both Werner and Thiele: he started from Werner's ideas of the divisibility of chemical affinity when discussing its distribution on molecules, and it ranks as a major and lasting discovery that his schemes of distribution involve a generalization of Thiele's theory of conjugation, as is to-day so readily appreciated in electronic terms.

Flurscheim's first paper of classical importance, published in the *Journal für praktische Chemie* in 1902, described the first rational explanation of orientation in aromatic substitution. In 1909–10 he published in the *Journal of the Chemical Society* two papers of like importance on the strengths of acids and bases. Here he was extending the application of his theory from the kinetic to the thermodynamic field, thereby showing that his valency redistributions apply not only to activated states but also to normal molecules. To-day, with the aid of the quantum theory, we re-express this, too, in electronic terms, and call the result mesomerism or resonance.

Flurscheim published many other papers of more limited importance. He never participated in the remoulding of his theories in conformity with the electronic theory of valency and quantum mechanics. However, the largely correct form of Flurscheim's theories made this task of recasting them a particularly easy one for others.

His discovery of tetranitroaniline, perhaps the most powerful of known explosives at the time of its discovery, was an accidental result of his work in the Fleet laboratory, directed as this was to the experimental control of his theoretical ideas. It was an accident that he sometimes regretted, inasmuch as it led him into commercial work, to which he was not well suited. However, it enabled him to render notable service during the First World War, when, on the request of the late Lord Moulton, he undertook supervision of the large-scale manufacture of this explosive in the United States. During the Second World War he worked as gas identification officer for the A.R.P. authorities.

Flurscheim did not make human contacts easily or treat them lightly. He was devoted to his family, and to a few firm friends. His chief personal hobbies were travel and climbing. In 1903 he visited New Zealand, where his father, Michael Flurscheim, lived, and there made acquaintance with the New Zealand Alps. He knew the Alps of Europe very well. He leaves a widow, a daughter and a son.

C. K. Ingold

NEWS and VIEWS

Chemistry at University College, London: Prof. D. P. Craig

A new chair of chemistry at University College, London, has been instituted, and Prof. D. P. Craig, of the University of Sydney, is to be its first occupant. He will take up the duties of the chair in 1956. Prof. Craig took his first degree with first-class honours in chemistry in 1940 in the University of Sydney, where he remained as Commonwealth Research Fellow until 1942. During 1942–44 he served with the rank of captain in the Australian military forces. In 1946 he was appointed lecturer in chemistry in the University of Sydney, and during 1946–50 he was Turner and Newall Fellow in the University of London, being appointed lecturer in chemistry at University College, London, in 1950; since 1952 he has been professor of physical chemistry in the University of Sydney. Prof. Craig's research career is that of an experimental physical chemist with deep knowledge of, and interest in, the theory of chemistry. He has published work on co-ordination compounds with particular reference to the nature of metal-ligand bonds, on aromatic character and the conditions for its appearance, on the excited states of unsaturated and aromatic molecules, on the excited states of crystals, and on the relation between molecular and crystal states. He has also contributed to the methodology of quantum mechanics by introducing configuration interaction into molecular orbital theory, and clarifying the role of polar structures in valency-bond theory. The addition of so accomplished a theoretician to the Chemistry Department of University College, where co-ordination chemistry, molecular spectroscopy and crystal chemistry are all intensively studied, seems particularly appropriate.

Sir William Hamilton (1805–65)

One of the most brilliant mathematicians of modern times, William Rowan Hamilton was born in Dublin one hundred and fifty years ago, at midnight between August 3 and 4, 1805, of a Scottish family that had settled in Ireland. He was a precocious child, being able to read Hebrew at the age of seven; at twelve he had mastered Latin, Greek and the leading Continental languages, and had acquired some knowledge of Syriac, Persian, Arabic, Sanskrit, Hindustani and Malay. Quite early he showed his genius for mathematics, and in his

seventeenth year detected an error of reasoning in Laplace's "Mécanique céleste". At Trinity College, Dublin, he was first in all his examinations and, while still an undergraduate, he predicted in 1833 by the aid of mathematics the internal conical refraction of light, which was verified experimentally in the same year by H. Lloyd. Hamilton was then appointed John Brinkley's successor in the chair of astronomy; he later became Astronomer Royal for Ireland. From 1843 onwards Hamilton devoted his life to the elaboration of his theory of quaternions, which was announced in "Lectures on Quaternions" (1853) and posthumously in "Elements of Quaternions" (1866). As a writer he was sometimes obscure and metaphysical, but he excelled as a fluent and ornate lecturer. He was knighted in 1835, was elected president of the Royal Irish Academy in 1837, and died on September 2, 1865, at the age of sixty, worn out physically and mentally.

Shortage of Scientific Workers and Teachers in Great Britain

In a debate in the House of Lords on July 5 on exemption from National Service, Lord Cherwell pressed again for the exemption of highly trained scientific workers, especially those engaged in high-grade research in the universities. Lord Cherwell suggested that there was great lack of balance in limiting deferment to fifty such scientists in a year when eight thousand agricultural workers are deferred each year; but Lord Carrington, replying for the Government as Parliamentary Secretary to the Ministry of Defence, stated that the Government has not yet received fifty applications from the universities for deferment under this scheme, and thought that it is much too early to judge how well this scheme, introduced earlier this year, is working. Lord Carrington also referred to a scheme, introduced since 1949, under which science and engineering graduates have been deferred for employment on a limited number of research and development projects mostly connected with the defence programme; and he emphasized the need of the Armed Services for technical graduates, particularly for younger workers with degrees in engineering, physics and mathematics. It has been estimated that in 1955 the Services will recruit less than half their requirements, and graduates in science are also badly needed by the education branches of all three Services for teaching in technical training colleges.

The debate was thus related to an adjournment debate in the House of Commons later in the week on the shortage of science teachers—a matter to which Lord Cherwell also referred, as did Lord Hull and Lord Glyn, whose purpose in tabling the motion was to emphasize the importance of giving technical and technological education and research a very high place in the affairs of the country. In raising this question in the Commons on July 8 and asking the Government what steps it proposes to take to meet the shortage, Dr. Horace King supported the exemption of science teachers from national service, or at least the exemption of those who had completed their initial or basic training, and Mr. E. C. Willis pointed out that the Appleton Committee had recommended the exemption of teachers with first- or second-class honours in mathematics, physics or chemistry, as being the only sure means of getting more teachers quickly. In replying for the Government, Mr. Dennis Vosper, Parliamentary Secretary to the Ministry of Education, declined to discuss the question of deferment; he pointed out that the teaching profession itself is divided on the question, that deferment would make a comparatively small contribution to the removal of the shortage, and that it would involve a breach in the principle of universality. He did not think that too much importance should be attached to the proposal in trying to solve the larger problem. Mr. Vosper said that the present shortage of science teachers is less than expected, recruitment having exceeded the forecast; during the period March 1952–March 1954, the number of graduate science and mathematics teachers in maintained primary and secondary schools in England and Wales increased from 11,022 to 11,615. The main difficulty is in quality, and the real gravity of the problem was in the anticipated increase of 650,000 in the number of senior pupils by 1960 compared with 1954, with the consequent demand for a further 3,200 graduate science teachers. Mr. Vosper referred to the possibility of making conditions of service more attractive for teachers of science and mathematics, and said that the Minister hopes shortly to advise local education authorities as to the possibility of paid leave to teachers to take part in research; but he thought that the real solution to the shortage lies in a change in the public esteem of the teaching profession and an increasing public awareness of the needs of science.

Personnel Research in the Royal Navy

The record during the Second World War of the Royal Navy's concern with the safety and efficiency of its personnel can be found in the volume on medical research in the "Official Medical History of the War" (1953). In the post-war period the alliance between the Navy and the Medical Research Council in this field of research has continued vigorously and fruitfully. An up-to-date survey of naval personnel research (Admiralty Bulletin 67, pp. 12; Department of Chief of Naval Information, Admiralty, London, S.W.1; 1955) has now been written by Surgeon-Commander Crosfill, the present secretary to the Royal Naval Personnel Research Committee. The survey is a record of progress both in occupational hygiene and that branch of operational research for which the name ergonomics has been coined and which is concerned with the efficiency of the operator in his working environment. Commander Crosfill gives an informative and readable account of the important work sponsored by the various sub-committees of the main Committee. It is quite clear that the *ad hoc* work has nearly always been based on, and been a fruitful source of, much fundamental investigation. This is evident, on the psychological side, in studies of multi-channel communication, of various kinds of pressure and velocity control systems, and the effects of noise, all of which raise fundamental questions of vigilance, perception, proprioceptive 'feed-back' and skill. On the physiological side, studies of working efficiency in abnormal climates have yielded a great deal of basic data on human heat regulation, acclimatization and limits of heat tolerance and have led to improvements in the design of climatological 'indices' and the introduction of the ionization anemometer. Perhaps the most spectacular of the investigations is that sponsored by the underwater physiology sub-committee in connexion with the problem of submarine escape. This work has led to the development of the technique of escape by 'free ascent', and has made a

breathing set unnecessary. Other interesting topics in the report are concerned with survival at sea, nutrition in the arctics and the tropics, anatomical problems of seating and sighting, and the use of standardized photographs for the anthropometry of naval personnel.

Hydraulics Research Station, Wallingford : Report for 1954

THE report of the Hydraulics Research Board for 1954, with which is published the report of the Director of Hydraulics Research (pp. 52+11 plates. H.M.S.O., London, 1955 ; 5*s*. net), summarizes the work on loose-boundary hydraulics done at the Hydraulics Research Station, Wallingford, Berks. The greater part of it is concerned with ten model investigations and field studies of estuaries, river improvement schemes, and dock and harbour modifications, carried out at the request of various official bodies. Of fundamental work of more general application, there is at present comparatively little ; but comments at various points in the report suggest that experience gained from these miscellaneous investigations is gradually indicating the directions in which more general research should be pursued. Topics in which work has already begun include the use of radioactive tracers for indicating the movements of silt or mud, the determination of the effect of wind on wave propagation, and a study of the factors affecting cyclic channel movements in an estuary and the development of meanders. The report generally is of the high standard of presentation and lucidity that one expects from a technical publication of the Department of Scientific and Industrial Research ; but a more distinctive grouping of the various topics covered in it would make for an easier appreciation of the range of interests and activities of the Research Station.

Measurement of Pressure with the Mercury Barometer

No. 9 in the series "Notes on Applied Science", of the National Physical Laboratory, Teddington, is entitled "Measurement of Pressure with the Mercury Barometer" (pp. 15+1 plate. London : H.M.S.O., 1955 ; 1*s*. net). Reference is made to the new rationalized system of barometer conventions which came into operation on January 1 (see *Nature*, **174**, 1127 (1954), and British Standard 2520) ; but the main purpose of the pamphlet is to assist those workers in industry and in research laboratories who are concerned with the measurement of gas pressures by means of a mercury column. Pressures in the range 0–1,200 millibars are dealt with, and the accuracy considered is of the order of $\pm$ 0·1 millibar. The fundamentals of pressure measurement are briefly outlined, and then the two main categories of barometers, the Fortin and Kew types, are described, together with the factors which should be considered in choosing a barometer for a particular application. Valuable advice as to the proper methods of transport, storage and installation of barometers is given, and the observational procedure to be adopted and the various corrections to be applied to the readings taken are discussed and illustrated by a particular numerical example. Finally, a short description is given of the testing procedure followed at the National Physical Laboratory. This includes an illustration of the Laboratory's primary standard barometer, which is nearing completion.

A Mobile Bone Meal Factory in Africa

THE deterioration of African livestock shown by lack of productivity, poor calves and lack of resistance to parasitic infestation is in large measure due to insufficient phosphorus in the diet. No matter how excellent the animal husbandry practices may be, that is, rotational grazing, manuring and water supply, full response cannot be expected without making good the deficiencies of calcium and phosphorus. Phosphorus deficiency is a fundamental environmental factor which cannot be remedied otherwise than by supplementation of phosphorus. A mineral survey of Kenya soil, pasture and beasts has shown that in most cases there is a phosphorus deficiency. This deficiency may be made good, either in part or completely, by using mobile bone meal factories as envisaged by Dr. I. Mann (*Colonial Plant and Animal Products*, **4**, No. 4). These will make available on the spot substantial quantities of cheap phosphorus in the form of sterilized bone meal. The low capital expenditure necessary is entirely out of proportion to the benefits accruing to man and beast. Bones become a new and valuable cash crop, while the product offers the African the opportunity of improving his primitive husbandry and of rearing healthy and more productive livestock.

Factors in Clover Nodulation

THE effect of certain adsorbents on the nodulation of clover plants has been investigated by E. R. Turner (*Ann. Bot.*, N.S., **19**, 147 ; 1955). He has found that the addition of charcoal to the rooting medium of clover plants, inoculated with effective and ineffective strains of *Rhizobium*, leads to a stimulation in nodule production. The time-interval between inoculation and the first appearance of the nodules is reduced in the presence of charcoal. The author concludes that this stimulation is due to the adsorption by the charcoal of inhibitory compounds secreted by the clover roots. These compounds have, in fact, been eluted from the charcoal and have been shown to affect nodule production. It is suggested that, according to the concentration of the secretions in the eluates, either a stimulation or an inhibition of nodule formation may occur.

Biochemical Synthesis and Isotopic Tracer Technique

A GOOD many monographs have appeared in recent years on the use of isotopes as tracers to find how the body builds up complex materials from the breakdown products of the food. Dr. G. Popják, in a recently published lecture entitled "Chemistry, Biochemistry and Isotopic Tracer Technique" (Lectures, Monographs and Reports of the Royal Institute of Chemistry, London : No. 2, 1955 ; pp. 59), discusses the way in which the techniques of organic chemistry and of enzymology have been linked with the tracer technique in such work. Instead of trying to cover the whole field, Dr. Popják deals mainly with certain major topics—namely, fatty acids, cholesterol and the porphyrins—and discusses them in sufficient detail to show the interdependence of the three methods of approach in throwing light on the problems of biochemical synthesis. He underlines the need for continued close collaboration between the organic chemist and the biochemist in work of this type.

Museum Uses of 'Perspex'

IN the May number of the *Museums Journal*, Mr. R. A. Kennedy details two further uses for 'Perspex' in museum work. When this substance is used as a

protective covering for labels, it is found that in course of time dust accumulates between the card and the 'Perspex', and periodical removal and cleaning are a time-wasting process of little permanent value. A more satisfactory result is obtained by using 'Perspex' liquid cement containing chloroform to seal the label, and Mr. Kennedy gives practical details for doing this. The second use is for the reproduction of flint tools. It was found that 'Perspex' flakes in a similar fashion to flint when kept cold or, even better, when chilled. It is thus only necessary to use 'Perspex' of the correct colour, and by a combination of cutting out, filing, flaking and scraping an excellent imitation of a flint implement can be obtained.

Technical Hardness Measurement: International Conference in Bremen

An international conference on "Hardness Measurement in the Works" will be held in Bremen during September 22–23, in connexion with an exhibition there of modern hardness-measuring equipment of German and foreign manufacture. It is the second to be held in Bremen and is being arranged by the Arbeitsgemeinschaft für Fertigungstechnisches Messwesen (Working Committee for Metrology in Production) and the Institut für Härteprüftechnik (Institute for Hardness-testing Technology). At the conference, representatives from Austria, France, Germany, Great Britain, Japan and the United States will discuss actual problems of hardness measurement according to Rockwell, low-load and micro-hardness measurements after Vickers, hardness measurement on internal surfaces, as well as the possibilities and advantages of using technical statistics in the field of hardness testing. It is hoped to contribute to the establishment of internationally comparable hardness values, which are of much importance for technical products. Further details regarding the conference can be obtained from AFM, Verein Deutscher Ingenieure, Prinz Georg Strasse, Düsseldorf, Germany.

Association of Universities of the British Commonwealth

A Commonwealth Inter-University Conference will be held in Melbourne, Australia, during August 9–12, comprising the members of the Executive Council of the Association of Universities of the British Commonwealth, which holds an overseas meeting in the years between its quinquennial congresses. Similar meetings have recently been held in Canada (1949 and 1954), New Zealand (1950) and India (1951–52), but this is the first to be held in Australia. These conferences, which have been supported very generously by the Nuffield Foundation, provide the opportunity for discussion of matters of academic policy and Commonwealth inter-university relationships. The present meeting is to be presided over by Mr. A. P. Rowe, vice-chancellor of the University of Adelaide, and chairman this year of the Association of Universities of the British Commonwealth, and each Commonwealth country will be represented by one or more university executive heads, the United Kingdom party comprising Dr. R. S. Aitken (Birmingham), the Right Hon. H. U. Willink (Cambridge), Dr. D. W. Logan (London) and Mr. C. H. Wilson (University College, Leicester). The secretary of the conference is Dr. J. F. Foster, secretary of the Association of Universities of the British Commonwealth. The conference members while in Australia will visit other universities there and will attend the inauguration ceremonies of the new University of New England at Armidale, New South Wales, on August 4.

University of London

The title of professor emeritus in the University of London has been conferred on the following: Prof. J. H. Dible, on his retirement from the chair of pathology at the Postgraduate Medical School of London; Prof. Herbert Dingle, on his retirement from the chair of history and philosophy of science at University College; Prof. V. C. Illing, on his retirement from the professorship of geology (oil technology) at the Imperial College of Science and Technology; Prof. H. H. Read, on his retirement from the chair of geology at the Imperial College of Science and Technology.

The title of reader in botany in the University of London has been conferred on Sir Nigel Ball, Bart., in respect of his post at King's College, and that of professor of physics in the University of London on Dr. W. C. Price, in respect of his post at King's College.

The following appointments in the University have been announced: Prof. J. Duchesne, director of the spectroscopic radio-electric laboratory in the University of Liège, to the visiting professorship of Belgian studies in the University of London for a period during the second and third terms of the session 1955–56; Dr. Geoffrey Wilkinson, assistant professor of chemistry at Harvard University, to the University chair of inorganic chemistry tenable at the Imperial College of Science and Technology; Dr. W. G. Overend, lecturer in chemistry in the University of Birmingham, to the University readership in organic chemistry tenable at Birkbeck College; Dr. W. S. Pitcher, lecturer at the Imperial College of Science and Technology, to the University readership in geology tenable at King's College.

University of Leeds

The following appointments in the University of Leeds have been announced: Mr. D. C. Johnson, to be professor of mechanical engineering from January 1, 1956; Dr. D. Bradley, to be lecturer in mechanical engineering; Dr. D. A. Jones, to be lecturer in electrical engineering; Mr. S. C. Mitchell, to be lecturer in fuel technology; Dr. J. H. Robertson, Brotherton lecturer in the Department of Inorganic and Structural Chemistry, to be lecturer in the Department of Inorganic and Structural Chemistry; Mr. T. Wilson, to be lecturer in electrical engineering.

The University has acknowledged the following gifts, among others: £300 from the Yorkshire Agricultural Society, for the Department of Agriculture; £700 from Messrs. Joseph Booth and Brothers, Rodley, for the Department of Civil Engineering, to maintain a student for two years to undertake research work on the dynamic stresses induced in cranes; £3,000 for 1954–55 from the North-Eastern Division of the National Coal Board, for the Department of Mining; £940 from the Royal Society, for the Department of Physics, for research carried out by Dr. R. S. Tebble on the magnetic properties of metals and alloys at high temperatures.

Salters' Institute of Industrial Chemistry: Awards

The Salters' Company has elected M. J. Stephen to be a Salters' Fellow for the year 1955–56. Mr. Stephen, who is a graduate of the University of the

Witwatersrand, Johannesburg, obtained an M.Sc. degree in 1953 and is at present studying for the degree of D.Phil. under Sir Cyril Hinshelwood at Oxford. During the coming year he will carry out research under Prof. C. A. Coulson, at Oxford, on the mechanisms and rates of reactions. The Salters' Company has offered a scholarship to a student from Canada, and, on the recommendation of the National Research Council for Canada, C. G. Miller, of Queen's University, Ontario, has been appointed; Mr. Miller will carry out research during the year of tenure of his scholarship under Mr. R. P. Bell, of the University of Oxford. The Court of the Company has also elected the following to be Salters' Scholars for the year 1955–56: M. McLeman (Imperial College, London); W. L. Wilkinson (Cambridge); D. Charlesworth (Hull); P. L. Levine (Imperial College, London); D. M. McMahon (Queen's University, Belfast); W. Kemp (Glasgow); B. B. Hunt (Cambridge).

Colonial Service: Recent Appointments

THE following appointments have been made recently in the Colonial Service: J. H. Gisborne (principal agricultural officer, Northern Region, Nigeria), assistant director of agriculture (research), Northern Region, Nigeria; T. N. Greeves (deputy director of agriculture, Sierra Leone), director of agriculture, Sierra Leone; T. S. Jones (senior agricultural officer, Sierra Leone), deputy director of agriculture, Sierra Leone; M. A. Blane and F. A. Leeds (senior agricultural officers, Gold Coast), assistant directors of agriculture, Gold Coast; C. R. Dickson, J. T. W. Gray, R. Mulholland, J. H. N. Pitman, W. Smith and T. M. Wiszniewski (agricultural officers, Gold Coast), senior agricultural officers, Gold Coast; P. Peterson (meteorological officer, Singapore), scientific officer, Royal Observatory, Hong Kong; W. G. G. Forsyth (principal scientific officer, Colonial Microbiological Institute, Trinidad), director of the Colonial Microbiological Institute, Trinidad; C. Turner, agricultural officer, Kenya; K. A. Exelby, chemist, Government Chemist Department, Tanganyika; D. McKie, mineralogical chemist, Tanganyika; R. N. Cope, geologist, Federation of Nigeria; J. R. Baker, scientific officer (protozoologist), East African Tsetse and Trypanosomiasis Research and Reclamation Organization; W. N. Beesley, scientific officer (parasitologist), Helminthiasis Research Unit, Kumba; P. E. S. Whalley, entomologist, Uganda; P. J. S. Anderson, veterinary officer, Tanganyika; A. T. Carey, assistant adviser on aborigines, Federation of Malaya.

The Night Sky in August

FULL moon occurs on Aug. 3d. 19h. 30m., U.T., and new moon on Aug. 17d. 19h. 58m. The following conjunctions with the moon take place: Aug. 19d. 0h., Mercury 7° N.; Aug. 24d. 04h., Saturn 5° N. Mercury is too close to the sun for observation during August. Venus, which rises about forty-five minutes before sunrise up to the middle of the month, rises almost at the same time as the sun at the end of the month, and is unfavourably placed for observation during August. Mars, in conjunction on August 17, cannot be observed during the month. Jupiter, in conjunction on August 4, is visible towards the end of the month when it rises about two hours before the sun, and can be seen in the constellation Cancer, in which it has an eastward movement. Saturn sets at 23h., 22h. and 21h. on August 1, 15 and 31, respectively; its eastward movement can be detected by comparing its positions at various times with the second-magnitude star α Librae from which it is receding. Its stellar magnitude varies from 0·7 to 0·8, the diminution in brightness being due to the increase in its distance from the earth by forty-five million miles. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Aug. 6d. 01h. 18·4m., ϰ Aqr. (*R*); Aug. 7d. 01h. 56·8m., ϰ Psc. (*R*); Aug. 12d. 03h. 18·9m., *A* Tau. (*D*); Aug. 29d. 22h. 32·4m., 57 Sgr. (*D*). *D* and *R* refer to disappearance and reappearance, respectively. The Perseid meteors attain a maximum about August 10–13; moonlight will interfere to some extent with observations during that period.

Announcements

DR. A. NEUBERGER is resigning from the chairmanship of the Editorial Board of the *Biochemical Journal* on October 1, and will be succeeded by Dr. A. G. Ogston. The editorial office of the *Journal* will be transferred from the National Institute of Medical Research at Mill Hill to the Lister Institute of Preventive Medicine, Chelsea Bridge Road, London, S.W.1, as from September 1. Communications should be addressed from that date to Mr. F. Clark, secretary to the Editorial Board, *Biochemical Journal*, at the Lister Institute.

A SYMPOSIUM on "Cavitation in Hydrodynamics" will be held at the National Physical Laboratory, Teddington, Middlesex, during September 14–17. Attendance will be by invitation, and those interested are asked to communicate with the Director of the Laboratory.

THE Universities Federation for Animal Welfare is holding its summer school this year at Westham House, Barford, Warwick, during September 24–October 1. There will be expeditions to a dairy farm, Dudley Zoo and a slaughterhouse, and lectures by experts on the following topics: animal behaviour, animals in zoos and circuses, slaughtering methods, animals in research, dairy husbandry and whaling. The fee for the school is five guineas (three guineas for students). Further information can be obtained from the Branch Organizer, UFAW, 7*a* Lamb's Conduit Passage, London, W.C.1.

THE July–September 1953 number of the "Bibliography of Articles appearing in Turkish Periodicals", issued recently by the Turkish National Institute of Bibliography, Istanbul (pp. 116. Istanbul: Maarif Basimevi), contains a further seven hundred entries given, as previously, in French and Turkish and arranged under the first two figures in the Decimal Classification. Entries are limited to title, author and reference. There are an author index and a list of periodicals covered.

A REPORT of the proceedings of the 1954 Conference of the Universities of Great Britain and Northern Ireland, held in London during December 17–18, 1954, is now conveniently available in pamphlet form (pp. 110. London: Association of Universities of the British Commonwealth; 1955; 2*s*. 6*d*.). It includes the text of the speeches of Dr. E. J. F. James and Prof. R. E. Peierls at the important discussion on the supply of teachers for mathematics and science, those of Mr. J. F. Wolfenden and Prof. H. S. W. Massey at that on whether undergraduate courses of study are overloaded, and of H. R. F. Harrod and Prof. J. F. Baker in opening the discussion on the retiring age for university teachers.

BRITISH FOOD MANUFACTURING INDUSTRIES RESEARCH ASSOCIATION

OPEN DAY

THE fine modern laboratories of the British Food Manufacturing Industries Research Association at Leatherhead, Surrey, were occupied in the latter part of 1950, and the opening ceremony performed in November of the following year was then made the occasion of an open day[1]. On June 21 last the laboratories were once again thrown open to representatives of member firms, while representatives of other research organizations, of the scientific, technical, trade and national Press, and others were present by invitation. Some three or four hundred visitors saw exhibits illustrating the course of research during the past four years and the main aspects of the current research programme.

The interests of the Research Association cover a wide range of manufactured foods, with the exception of flour-milling, bread and bakery products, dairy products, and fruit and vegetable canning, all of which are the concern of separate research organizations. The research programme may be divided into three main categories: analytical problems in the routine control of quality; problems directly concerned with particular aspects of food manufacture; and more general investigations into fundamental principles with a bearing on the quality of the manufactured foods concerned. Some aspects of the work having wider scientific interest are outlined below.

The rheological properties of certain foods, including such diverse products as toffee, margarine, chocolate (in its fluid state), and starch, gelatine, agar and pectin jellies, have received considerable attention. A number of experimental pieces of apparatus were displayed, each designed to measure the force required to deform, or cause flow in, margarine and its allied product, compound cooking fat. One of these in particular, the 'extrusion plastometer', shows much promise in relating plasticity and 'spreadability' to readings taken on the instrument. Chocolate is processed during manufacture in a liquid state, and measurement of its rheological properties is of great importance in the chocolate industry. It has been shown to behave as a Bingham material, and measurement of its 'viscosity' raises considerable difficulty in factory practice. A number of commercial and experimental instruments which have shown promise of proving useful in factory control were exhibited. Investigations into the pasting of starch have been carried out by means of the corn industries viscometer. The measurement of the properties of jellies of various types is of interest in a number of foodstuffs. The Research Association has recently contributed largely to the design of the F.I.R.A. jelly tester, which incorporates several refinements, particularly in respect of design of the spade and reduction of friction, in comparison with the older B.A.R. tester. Recent work on the gelling properties of agar has shown how the instrument may be used for characterizing jellies and obtaining information beyond the measurement of pure 'jelly strength'.

The Research Association is studying the plastic composition and crystallization behaviour of cocoa butter and other fats through determinations of the specific heats and heat contents over a wide range of temperatures. From the measurements obtained, the percentage of liquid phase at a given temperature may be calculated. An adiabatic calorimeter has been constructed for the purpose of these studies, a description of which will shortly be published elsewhere by Mr. E. H. Steiner. The procedure followed is intermediate between that described by A. E. Bailey *et al.*[2] and that of J. Straub and R. N. M. A. Malotaux as adapted by S. V. Vaeck[3]. The investigation is important in the study of the tempering of chocolate and the use of alternative fats in certain types of confectionery. The control of particle size is of importance in many food products, such as icing sugar, cocoa powder, chocolate and starch. Among the exhibits were a commercial vortex sieve for cocoa powder, a modified Andreasen sedimentation apparatus for chocolate and a Lea and Nurse air-permeability apparatus for the determination of specific surface of several materials.

In the field of biochemistry, a study of the nature of the changes undergone by meat products, particularly colour changes in sausages, ham and other cured meats, is being made from a fundamental point of view; a note on one aspect of this work was recently published by J. I. Anderton and D. J. Locke[4]. The separation and study of vitamin A and related substances in liver oils is being undertaken by the use of a 'short-path' molecular still, chromatographic methods and the use of the quartz spectrophotometer. Fruits for jam-making and brined vegetables for the manufacture of pickles are both subject to undesirable tissue breakdown under certain conditions. The part played by pectolytic enzymes of the fruits and vegetables and those produced by moulds naturally present on fresh fruit and vegetables is being investigated in this respect. The Research Association maintains an extensive microbiological laboratory for the study of both the desirable organisms that are necessary to such processes as the curing of bacon and the preparation of pickles, and the spoilage organisms which are a source of trouble in canned meat and fish products, and in pickles and sauces. Investigations of the thermal death-rate characteristics of mould spores which may cause spoilage in jam and of the bacteria and yeasts responsible for spoilage in pickles are being carried out.

On the technological level, the Research Association maintains pilot plant for studying the rate of heat penetration into canned goods under commercial conditions, and a laboratory-sized apparatus for carrying out pasteurization tests on jars of pickled onions has recently been designed and constructed. The packaging of manufactured foods is an integral part of the interests of the Research Association. While it does not concern itself with the study of the properties of the various wrapping and packaging materials, it is concerned with the choice of material best suited to particular products. In this connexion, a number of studies are undertaken, such as measurement of the vapour pressure of confectionery products, the protection of metal closures on glass packages from any corrosive effects due to the nature of the product packed in them or, conversely, discoloration of the product in contact with the closure, and the effects of transparency and

air-permeability of wrappers for margarine. The permeability of rubber sealing rings to gases and volatile substances is a cause of deterioration in meat and fish pastes, and the most desirable formulation for such rubber rings is being sought in collaboration with the manufacturers.

[1] See *Nature*, **168**, 1108 (1951).
[2] *Oil and Soap*, **21**, 293 (1944).
[3] *Int. Choc. Rev.*, **6**, 350 (1951).
[4] *Nature*, **175**, 818 (1955).

RADIATION CHEMISTRY OF SOLUTIONS

THE fifth annual meeting of the Société de Chimie Physique was held in Paris during May 31–June 3, the subject of the meeting being the chemical effects of ionizing radiation. It was organized by Prof. G. Emschwiller and was attended by chemists and physicists from Europe, the United States and the U.S.S.R.

Radiation chemistry is complicated by the fact that the primary events are confined to the tracks of the ionizing particles. It was pointed out that in aqueous solutions the yield varies with radiation quality, the principal change occurring in the range 6·5–25 keV./μ mean linear energy transfer of the radiation. On the assumption that only those parts of the ionizing tracks where the linear energy transfer is greater than 25 keV./μ are effective, and taking δ-rays into account, a curve for the efficiency of different radiations has been calculated which is in good agreement with the experimental data for the molecular hydrogen yield (L. H. Gray). A tentative mathematical picture was given of the kinetics of radicals formed in a track (J. L. Magee). With increasing intensity, the tracks overlap and the kinetics of homogeneous solutions apply. This change was demonstrated using diphenylpicryl hydrazine in chloroform (A. Chapiro). There is a possibility that excited water molecules play a part in the indirect effects in dilute solutions (J. Weiss). However, the strict proportionality of fluorescence and sodium salicylate concentration in an aqueous solution exposed to α-radiation suggests the absence of indirect excitation of the solute (N. Miller).

The most useful system for the chemical measurement of dose is still a solution of 0·001 *M* ferrous ions in 0·1 *M* sulphuric acid. Several recent determinations for X-rays and β-rays have all favoured a value close to $G_{Fe^{+++}} = 15{\cdot}5$ molecules per 100 eV. (N. Miller; A. J. Swallow; M. Cottin). An accurate determination has been carried out with 2 MeV. electrons and gives $G_{Fe^{+++}} = 15{\cdot}45 \pm 0{\cdot}11$ (R. H. Schuler and A. O. Allen, reported by N. Miller). The kinetics for the oxidation of 10^{-3} *M* ferrous ions in 0·1 *M* sulphuric acid are fairly well understood, but are totally inadequate to explain the high yield $G_{Fe^{+++}} = 63$ obtained in aerated solutions of 2×10^{-3} *M* ferrous ions in 4 *M* sulphuric acid (Proskurnin, quoted by S. S. Medvedev). The sensitivity of yield to the presence of impurities was demonstrated with the Fe^{++} system (N. Miller; C. Vermeil). For the measurement of exceptionally high doses, oxalic acid was recommended (I. Draganic). The measurement of dose by the ionization method depends upon the energy *W* required to form one ion-pair in air. Recent measurements with polonium α-rays give values close to $W = 35{\cdot}5$ eV., in agreement with older data. New results for fast electrons obtained from a comparison of absolute counting-rates and ionization measurements of sodium-24, cobalt-60, gold-198, iodine-131 and phosphorus-32 lead to a value of $W = 34 \pm 1$ eV. in air, differing slightly from $W = 32{\cdot}5$ eV., the value widely used in radiological work (W. Emery, reported by L. H. Gray).

It was generally agreed that the initial products in the radiolysis of water are the free hydrogen and hydroxyl radicals and the molecular products hydrogen and hydrogen peroxide. The mechanism giving rise to the formation of the molecular products is not understood, but evidently it occurs in those parts of the tracks where the linear energy transfer is very high. The yields of molecular hydrogen are less affected than the yields of hydrogen peroxide by the presence of various solutes (M. Lefort and M. Cottin). New light was thrown on these processes by studies of radiation-induced polymerization and of the production of hydrogen peroxide in gas-free aqueous solutions of acrylonitrile. Both the monomer and polymer are inert to hydrogen peroxide, but readily combine with hydrogen and hydroxyl radicals. The yield of hydrogen peroxide varies with monomer concentration. It is at a maximum at 10^{-2} *M* and drops by a factor of 6 at the highest monomer concentration used, 0·5 *M*, when the monomer reacts with precursors of hydrogen peroxide even in the densest parts of the tracks (E. Collinson, F. S. Dainton and G. F. McNaughton). No similar demonstration of precursors of molecular hydrogen has yet been made. It might be formed directly from one water molecule, but the dependence of the yield on the linear energy transfer suggests a recombination process (M. Haïssinsky; G. Stein; M. Magat). Oxygen-18 has been used in a study of the production and decomposition of hydrogen peroxide by radiation (E. J. Hart, S. Gordon and D. A. Hutchinson).

Some of the aqueous solutions investigated are of biochemical interest. Irradiation of phosphoric acid esters of the homologous series of methyl to amyl alcohols shows that the larger molecules are more stable. The main products of decomposition are inorganic phosphate, acyl phosphate, aldehyde and hydrogen peroxide. All solutions show an after-effect if irradiated in the presence of oxygen. Analogous results with solutions of mononucleotides were reported (R. W. Wilkinson and T. F. Williams; G. Scholes; M. Daniels). Radiation effects on catalase in dilute aqueous solution show that quantitative results depend to a very large extent on the purity of the enzyme preparation. The enzyme is inactivated by hydroxyl radicals and not by hydrogen radicals as has been previously assumed (W. M. Dale and C. Russell; P. Bonet-Maury and F. Patti; H. C. Sutton, quoted by L. H. Gray). In contrast, reduction processes occur in solutions of methylene blue, coenzyme I and diphosphopyridine nucleotide (G. Stein; A. J. Swallow).

Irradiation of aqueous solutions of polyvinylpyrrolidine and other water-soluble polymers leads to degradation if the concentration is less than 0·3 per cent, and to cross-linking if more than 1 per cent (A. Charlesby and P. A. Alexander). The mechanism of cross-linking, however, is not yet understood (A. Henglein; Y. Landler). Irradiation of air-free solutions of methacrylic acid leads to polymerization which continues after the end of the exposure. The resulting polymer, dried and exposed to air for several hours, can still initiate polymerization in new unirradiated monomer solutions (M. Fox and P. A.

Alexander). Similarly, irradiated dry polymers can initiate polymerization in their own or different monomer solutions, even months after the exposure, thereby forming so-called graft polymers. These show a mixture of the physical properties of the parent substances (A. Chapiro; M. Magat). The reactions of diphenylpicryl hydrazine have been studied in great detail, showing that substitution occurs in the *p*-position of the phenyl groups (A. Henglein; W. Wild). Irradiated solutions of diphenylpicryl hydrazine show an after-effect lasting for several weeks. Some discrepancies between the experiments with this substance in Britain, France and Germany seem to have been due to differences in analytical procedures and conditions of irradiation (W. Wild; A. Chapiro; A. Henglein). The loss of colour of diphenylpicryl hydrazine, irradiated in mixtures of organic solvents, does not follow a simple additive law, indicating energy transfer from one solvent molecule to the other (A. Chapiro; S. S. Medvedev). Similar evidence of a non-additive effect has been observed in the luminescence of *p*-terphenyl induced by γ-irradiation in mixtures of benzene and *cyclo*hexane (M. Burton, P. J. Berry and S. Lipsky). The use of radiation as an energy source in preparatory organic chemistry was demonstrated in halogenation reactions of aromatic compounds and in the synthesis of methylene blue and other organic substances (D. E. Harmer, J. J. Martin and L. Anderson; J. Loiseleur).

Many of those who attended both this meeting and the Faraday Society Discussion on radiation chemistry in Leeds in 1952 felt that in Paris there was less controversy about possible radical intermediates, most of the new results falling into line with accepted schemes of radical formation and reaction. Even the concept of the 'molecular yield' which has had considerable prominence showed signs of giving way to interpretation in terms of these schemes.

M. Ebert
P. Howard-Flanders

POLAROGRAPHIC INSTRUMENTATION

FIRST SYMPOSIUM OF THE POLAROGRAPHIC SOCIETY

By invitation of Prof. F. S. Dainton, the first symposium of the Polarographic Society was held in the Chemistry Department of the University of Leeds on May 25. In its emphasis on the design of polarographic instruments, this meeting is believed to have been the first of its kind to be held in Great Britain. After Prof. Dainton had extended a welcome to the Society, the chairman mentioned the steps leading to its recent formation and briefly outlined its objects.

In most cases, those reading papers explained the essential principles of the circuits employed in their instruments. C. Wontner described a simple manual polarograph and demonstrated its use in obtaining current/voltage curves. These can be plotted with surprising speed because of the semi-automatic location of the voltage scale in a series of 10-mV. steps. By virtue of a magic-eye null-point detector, the manual polarograph described by G. O. Jolliffe measures the true maximum current and so eliminates assumptions about the detector's equation of motion. This instrument is also of interest to the polarographic research worker in that it contains facilities for measuring both current and voltage potentiometrically.

A pen-recording polarograph, which possesses a photovoltaic amplifier of very short time-constant, was described by E. A. Wood and Mrs. B. Lamb. The design of an associated condenser/resistance differentiating unit for use in derivative polarography was also explained. G. L. Young dealt with a pen-recording instrument involving a different type of amplifier and paid special attention to the theoretical aspects of an attachment which enables the instrument to record true derivative peaks by the a.c. polarographic method of Breyer and Gutmann.

After dealing with the rather differently shaped waves encountered in cathode-ray polarography, G. F. Reynolds gave an outline of the theory by explaining the equations of Randles and Sevcik. Apart from being more sensitive than conventional instruments, the Chemical Inspectorate, Randles-type, single-sweep polarograph can also be operated with greater speed and simplicity. In its resolution of closely spaced steps and compensation for a preceding step, the instrument's normal performance is between that of the 'conventional' and the 'derivative' polarograph. However, the incorporation of a derivative circuit enables it where necessary to achieve the resolution of the derivative polarograph together with a much greater sensitivity. Mr. Reynolds expressed the view that, in general, the sensitivity and applicability of the cathode-ray polarograph are equal to that of the square-wave polarograph at its present stage of development. The design principles of a single-sweep cathode-ray polarograph were then given by H. W. Rowe-Leete, who also dealt with the electronics in terms of block diagrams.

By way of a contrast to these purely instrumental contributions, Mrs. N. Luthy read a paper on the application of the polarograph to pyrimidine chemistry, with particular reference to the detection of the —S—S— bond.

A. L. Glenn

LIBRARY RESOURCES IN THE MANCHESTER AREA

A CONFERENCE on library resources for industry and commerce in the Manchester area was held in Manchester on March 10 by the Northern Branch of Aslib. The speakers were Mr. D. I. Colley, Manchester City librarian; Mr. V. D. Freedland, information officer of the British Hat and Allied Feltmakers Research Association; Mr. L. L. Ardern, librarian of the Manchester College of Technology; and Mr. R. Brightman, bibliographer of the Dyestuffs Division, Imperial Chemical Industries, Ltd.

In his survey of the services provided by the City Library, Mr. Colley emphasized their diversity. The main point is that these services have to meet the varied need of the rate-payers who pay for them. The commercial and technical libraries, while important and highly developed, are but two sections. This dependence on local finance necessarily limits developments. This is unfortunate, he said, because a census taken during 1954 showed that some 40 per cent of the users of the reference libraries were not rate-payers. Moreover, an analysis of this 40 per cent showed that Manchester is not only providing a

regional service but also a national, even international, one. In these circumstances, Mr. Colley maintained, it does not seem unreasonable to seek national support.

The major part of Mr. Freedland's paper consisted of an analysis of the holdings of some forty special libraries situated within a radius of twenty miles of the centre of Manchester. It was based on some of the replies to a questionnaire issued by Mr. A. L. Smyth, of the Reference and Special Libraries (North-west Group) of the Library Association. For convenience of presentation, Mr. Freedland grouped them under broad headings such as chemical production, textiles, engineering and the production and distribution of fuel and power. There are, he regretted, certain libraries which he was unable to include in his survey as they appeared to pursue a policy of non-co-operation in any of the various schemes for mutual assistance and collaboration.

Mr. Ardern spoke on the Manchester College of Technology Library and its assistance to industry. It began in 1824 as the library of the Manchester Mechanics Institute, and it still has many hundreds of the original volumes, of particular interest being the collection which had belonged to J. P. Joule. A few weeks ago the draft of a twelve-page letter which Joule had written in 1853 to William Hopkins, the Cambridge scientist, was found in one of these books. One of Joule's note-books, which was not recorded when Dr. Lowery described them in 1931, is in the library.

The library carries a stock of forty thousand volumes, five hundred current periodicals and the theses awarded for the degree of master of technical science in the University of Manchester. A large collection of standards is maintained, including those of the American Society for Testing Materials, the Society of Automotive Engineers and the Society of Plastics Industry. Many loans are made to industry, and the library will continue to welcome inquiries.

Mr. Brightman addressed the meeting as a library user. The public library, he thought, will be most useful to the firm which already possesses its own information service, and its chief value is in meeting marginal needs. Such a service can only be given if the public library does not fall below a minimum size. By co-operation, industry expands the public library service, and this implies development upon a regional basis. But it is not possible wisely to plan regional developments without regard to the national library system as a whole. The Royal Society's Scientific Information Conference in 1948 urged the Government to give increased support to central scientific libraries and stressed the need for co-operation in local areas. The Advisory Council on Scientific Policy appointed its own Scientific and Technical Information Committee, which reported on the needs of a national library of science and inventions, and plans for a new science centre were approved in principle by the Government in 1950. In December 1952, however, the Minister of Works announced the postponement of the whole scheme—even its planning. Apart from a protest in *Nature* and by Dr. Colgate in his Armstrong Memorial Lecture, this decision was unchallenged.

Last year, however, the Advisory Council expressed the hope that steps would be taken without undue delay to implement the scheme, and endorsed a report by its standing committee that there is a need for a new science lending-library outside London, preferably in a place easily accessible to the industrial areas of the North and Midlands, and that this library should be the centre of a regional loan system based on selected municipal libraries. It is understood that the Government is now considering this.

The discussion which followed the four papers concentrated on the possibilities of achieving closer co-operation between local libraries and on the ways of bringing pressure on the Government to proceed with the science centre. The Northern Branch Committee was urged to take the matter up.

A. R. CAMERON

RADIO COMMUNICATION BY WAVE SCATTERING

IT has been known for some twenty years or more that in addition to the normal process of reflexion at the various regions of the ionosphere, by means of which most long-distance communication is conducted, radio waves could be scattered in various directions from the point of incidence on the ionosphere. Such scattered radiation is usually very weak and not easily detected by normal methods of reception. In 1952, however, a paper was published by a group of workers in the United States describing experiments conducted on a frequency of 49·8 Mc./s., during which easily measurable signals were obtained over an experimental path 1,245 km. long. While the strength of the observed signals passed through a maximum at about midday and a minimum at about 20 hr., there was no failure over a period of several months resulting from conditions in the scattering medium.

The success of such experimental transmissions relied on the concentration of the emitted radiation into a narrow beam directed at the correct angle to secure forward scattering from irregularities in the lower regions of the ionosphere. A narrow-angle receiving aerial was also used, directed so as to ensure maximum reception from the same portion of the ionosphere as was 'illuminated' by the radiation from the transmitter. Much interest was aroused by these and later experiments, which clearly offered the possibilities of opening up new channels in the very high frequency band between 30 and 100 Mc./s. for a limited range of distances between about 800 and 2,000 km.

While it has been known that further investigations were in progress in the United States, Canada and the United Kingdom, very little of the scientific or practical results obtained has so far been published. It is therefore of considerable interest to note the recent announcement by the Massachusetts Institute of Technology of the development of new methods of sending radio waves over useful distances for communications as a result of research conducted for the United States Air Force. Dr. W. H. Radford, head of the M.I.T. Lincoln Laboratory's communications division, is reported in *The Times* of July 18 to have said that the first application of these new systems would be in connexion with the defence of the United States and Canada. The use of very high frequency ionospheric scattering as referred to above is of particular advantage in high-latitude and arctic regions, where conditions in the ionosphere for normal high-frequency (30 Mc./s. and below) propagation are subject to storms, resulting in great variability and interruption of radio communications. It is understood that some circuits operating on these principles and using teletype transmission are already in operation.

In an analogous manner, radio waves in the ultra high frequency band above 300 Mc./s. can be used for communication over somewhat shorter, but still useful, distances of the order of 500 km., by forward scattering of the waves from irregularities in the troposphere at a height of a few kilometres. A similar use of high effective power, directive aerials and sensitive receivers is required but, on account of the higher frequency employed, a greater resulting bandwidth can be made available for normal radio telephony operation. Until more information is disclosed as to the scientific and practical results of the investigations in progress in various parts of the world, the full possibilities of communication systems based on the forward scattering of radio waves in the ionosphere and troposphere cannot easily be visualized. Further publication of the results of recent investigations in these fields will be awaited with interest by all those concerned with the future of radio communication.

VEGETATION OF THE ASSAM VALLEY

IN Vol. 9, No. 1, of *Indian Forest Records* (pp. iv + 87 + 4 plates. Delhi: Manager of Publications, 1954), J. B. Rowntree, formerly conservator of forests, Assam, writes on an "Introduction to the Vegetation of the Assam Valley". In 1938 Dr. N. L. Bor, on deputation among the head-hunters of the Aka Hills, Assam, wrote a detailed account of the vegetation of that area. A first attempt to classify the vegetation of India was made by Mr. (now Prof.) H. G. Champion in 1935 in "A Preliminary Survey of Forest Types in India and Burma". The area covered did not permit of great detail being given. The present work is an attempt to do the same for the whole of the Brahmaputra valley.

The object aimed at was to collect all the existing data on the subject, with additions from personal knowledge of all the communities described, especially with respect to the *Dipterocarpus–Mesua–Michelia* association and the *Shorea–Schima–Lagerstroemia* pro-climax. To the north of the Brahmaputra the river runs practically north and south, and from the foot of the hills the land drops on a gentler slope. The hill areas are covered with forests; but, owing to the prevailing habit of shifting cultivation (*jhuming*), the climatic climax formation is but rarely met with, and the forest is mostly of secondary growth. In most of India this practice was stopped by the British Government; but this action did not extend to the remote Assam of those days. As in the case of Africa, so here; Mr. Rowntree states: "In olden times when the population was kept in check by wars and disease no great harm was done, but nowadays with the population increasing (in places at alarming rates) this is no longer the case". The *jhuming* rotation is becoming shorter and shorter, and in places is down to three years. As a result, the ground-cover appears to be retrogressing from tree growth to bamboos and finally to grass, the soil is decreasing in fertility and erosion increasing from year to year, with floods silting up valuable plain land.

The main reserved forests lie along the foothills with detached blocks on higher land in the plains. The tropical evergreen formation is in Upper Assam, and the *Shorea robusta* association in Lower Assam. Among biotic factors man, as has been shown, plays a predominant part, followed by animals, giant climbers and epiphytes, insects, soil algæ, bacteria and earthworms.

Having disposed of the factors of climate, geology and soils and so forth, Mr. Rowntree, in a series of chapters, deals with the classification of the communities, the tropical *Cinnamomum–Amoora–Michelia* formation and its associates, the deciduous *Shorea* formation and other groups, grasslands and savannahs, and so forth. Appendixes give maps, and there are a few illustrations. To the forest officers and those interested in the flora of this little-known part of the world, the work should prove invaluable.

E. P. Stebbing

RELATIONSHIP BETWEEN CERTAIN COMPONENTS OF THE CYTOCHROME SYSTEM

By Prof. D. KEILIN, F.R.S., and Dr. E. F. HARTREE
Molteno Institute, University of Cambridge

OF the components of a typical cytochrome system only cytochrome *c* has so far been isolated in a soluble and completely pure state. By a very simple procedure[1], cytochrome *c* containing 0·34 per cent iron can be obtained from heart muscle on a large scale, while further purification[2–4] yields fractions with iron contents of 0·43–0·45 per cent. Although the properties of this isolated or exogenous cytochrome *c* are in general independent of the method of extraction and of the degree of purification, its catalytic activity, as determined with a heart-muscle preparation of cytochrome oxidase[5], is much lower than that of the endogenous pigment present in this preparation[4,6–9]. Furthermore, only exogenous cytochrome *c* combines with cyanide within the physiological range of *p*H[10–14].

These differences between the two forms of cytochrome *c* appear to favour the view that it undergoes a marked change on extraction. However, two considerations militate against this view. (1) Cytochrome *c* which has been obtained by a very mild method of extraction of washed heart-muscle mince with phosphate buffer has the same properties[10] as the pigment obtained by the usual, more drastic, method[1]. (2) The catalytic activity of the cytochrome system in a particulate heart-muscle preparation depends upon appropriate spatial distribution of all components of the system; in other words, upon an arrangement within the particles which assures their mutual accessibility. In this respect endogenous cytochrome *c* is more favourably placed for electron transfer reactions than is the exogenous pigment. That there is no essential difference between the exogenous and endogenous forms was demonstrated by a transformation of the former into the latter[10]. This was achieved by adding extracted cytochrome *c* to a washed heart-muscle mince previously made deficient in cytochrome *c*, and then

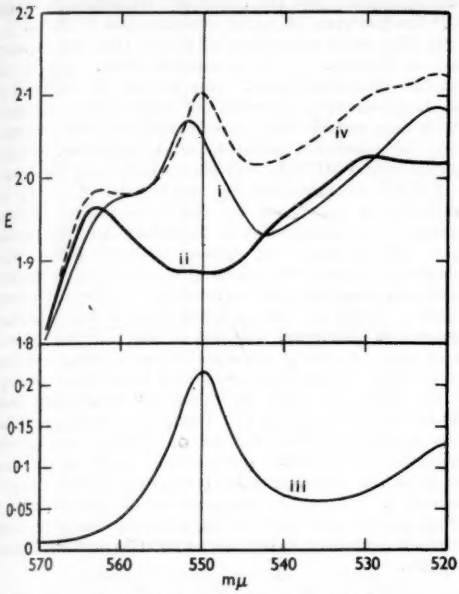

Fig. 1. Absorption spectra of heart-muscle preparation reduced with succinate or with succinate + antimycin *A*. Effect of adding cytochrome *c* to the latter. (i) Preparation + succinate. (ii) As (i) + 20 μgm./c.c. antimycin *A*. (The solution was aerated periodically to maintain all cytochromes except *b* in the oxidized state.) (iii) 16 μ*M* cytochrome *c* + sodium dithionite. (iv) Optical mixture of solutions (ii) and (iii). *E* = extinction (optical density)

obtaining from this mince our standard type of muscle preparation[5]. The now re-incorporated cytochrome *c* was found to be indistinguishable from the normal endogenous cytochrome *c* of such preparations[10].

Variations in the Position of the c-Band of the Cytochrome Spectrum and Evidence for an Additional Cytochrome Component

While the α-band of reduced cytochrome *c* in solution lies at 550 mμ, the position of this band in preparations of heart muscle and other tissues, as well as in certain bacteria, has been recorded spectrophotometrically as 551–552 mμ[15–20].

The study by conventional spectrophotometric methods of heart-muscle preparations suspended in buffers is scarcely practical since the loss of light by scattering is much greater than the decrease arising from absorption. It has been customary to add bile salts to such preparations, which leads to a considerable degree of clarification and, in addition, to plot difference spectra (for example, oxidized against reduced forms) in order to reduce still further the effects of scattering. Since bile salts have inhibitory actions on some catalytic components of the heart-muscle preparation, we have used high concentrations of sucrose in place of bile salts.

In order to determine as precisely as possible the relative α-band positions for soluble cytochrome *c* (horse heart) and for endogenous cytochrome *c* in the heart-muscle preparation, we have used a Hilger 'Uvispec' spectrophotometer fitted with a glass prism. The resulting high dispersion allows wavelength settings to be made accurately to 0·1 mμ in the greater part of the visible region. By reading extinctions at 1 mμ intervals and constructing a smooth curve the band maxima could be estimated with an error of $\pm$ 0·3 mμ. A comparison between a calibrated didymium glass filter and a solution of reduced cytochrome *c* in phosphate buffer *p*H 7·3 at 20° gave the position of the α-band of soluble cytochrome *c* as 550·0 mμ. Heart-muscle preparations were suspended, after isoelectric precipitation[5], not in the customary phosphate buffer but in a sucrose phosphate solution (200 gm. sucrose in 100 c.c. 0·25 *M* disodium phosphate) and examined in 0·5 cm. cuvettes. The extinction of these suspensions was 1·5–2·0 at 550 mμ. Repeatable readings of these high extinctions were obtained by using the makers' high-intensity filament lamp, taking extinction (*E*) readings against a blank cuvette containing paraffin-soaked filter paper ($E \sim 1$) and correcting for the extinction of the latter. Under these conditions it was possible to work with a slit-width of 0·2 mm., which is equivalent to a 5 mμ band-width at 550 mμ.

The results of our experiments can be summarized as follows.

(1) The position of the α-band of cytochrome *c* in heart-muscle preparations reduced with either sodium succinate or sodium dithionite is near 552 mμ (Fig. 1, (i)), the mean figure from numerous experiments being 551·7 mμ. In no case was the band position modified by treatment with cyanide (1 m*M*) or carbon monoxide.

(2) The equivalent band in a cytochrome *c*-deficient heart-muscle preparation, which is measured as a shoulder on the short-wave side of the band *b*, lies between 553 and 554 mμ (Fig. 2, (ii)).

(3) When a solution of cytochrome *c* (α, 550 mμ) is added to cytochrome *c*-deficient heart-muscle preparation in amounts approximately compensating the deficiency and the mixture is reduced with succinate or sodium dithionite, the α-band of the added cytochrome *c* is seen to be at 552 mμ (Fig. 2, (iv)). This band-shift could conceivably be due to four causes: (i) A reaction between exogenous cytochrome *c* and some constituents of the heart-muscle preparation which affects the absorption

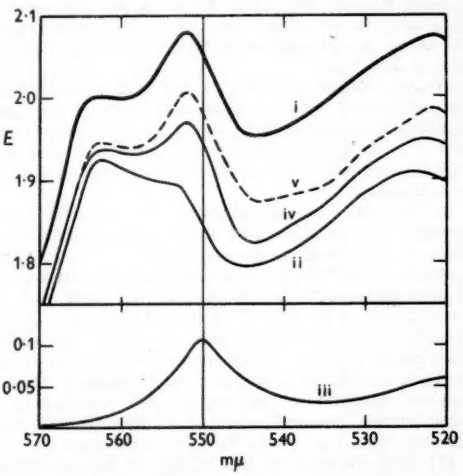

Fig. 2. Absorption spectra of normal and cytochrome *c*-deficient heart-muscle preparations and the effect of adding cytochrome *c*. (i) Normal preparation + sodium dithionite. (ii) *c*-Deficient preparation + sodium dithionite. (iii) 8 μ*M* cytochrome *c* + sodium dithionite. (iv) As (ii) + 8 μ*M* cytochrome *c*. (v) Solutions (ii) and (iii) in adjacent cuvettes (optical mixing). *E* = extinction (optical density)

spectrum of cytochrome *c*. (ii) An effect of the overlap of the α-bands of cytochrome *c* and cytochrome *b* (563 mμ). (iii) A result of light-scattering by the heart-muscle preparation. (iv) An effect of some other component with an absorption band close to that of cytochrome *c*. Each of these possible causes will be examined separately.

(i) The possibility of a reaction between exogenous cytochrome *c* and a constituent of the heart-muscle preparation was easily dismissed, since the shift of the α-band towards 552 mμ takes place not only when cytochrome *c* is added to cytochrome *c*-deficient heart-muscle preparation but also when they are mixed optically, that is, by placing a solution of cytochrome *c* and the deficient heart-muscle preparation in separate adjacent cuvettes in the light-beam (Fig. 2, (v)).

(ii) An effect of the absorption spectrum of cytochrome *b* can be readily eliminated. Thus, if a solution of cytochrome *c* is added to cytochrome *c*-deficient heart-muscle preparation and the mixture reduced with either ascorbic acid or cysteine, which do not reduce cytochrome *b*, the α-band of cytochrome *c* appears to be nearer to 552 mμ than to 550 mμ.

(iii) An explanation in terms of light-scattering is improbable since the addition of light-scattering material, such as milk, to a solution of reduced cytochrome *c* does not change the position of its absorption bands.

(iv) The shift of the α-band of reduced cytochrome *c* from 550 to 552 mμ must therefore be due to the presence in heart-muscle preparations of an extra pigment, which we shall temporarily refer to as *P*, with an absorption band lying near 550 mμ. The following experiments provide further evidence for this view and also reveal the nature and function of *P*.

(4) Since cytochrome *c* is the only cytochrome component which is known to be thermostable, it was of interest to determine the absorption maximum in the heart-muscle preparation after heat treatment. After heating heart-muscle preparation for twenty minutes at 70° and then reducing it with sodium dithionite or ascorbic acid, the only bands visible are those of cytochrome *c*, the α-band of which is now at 550 mμ.

(5) An optical mixture of reduced cytochrome *c* and untreated (that is, oxidized) heart-muscle preparation shows an α-band at 550 mμ. This indicates that *P* undergoes oxidation and reduction and that only its reduced form affects the spectrum of reduced cytochrome *c*.

(6) In an optical mixture of reduced cytochrome *c* in solution and heart-muscle preparation reduced in presence of antimycin *A* with either succinate or DPNH (reduced coenzyme I), the α-bands of cytochromes *c* and *b* are at 550 and 563 mμ respectively (Fig. 1). If it is assumed that *P* is a cytochrome type of pigment showing only diffuse absorption in the visible region when it is in the oxidized form, this experiment indicates that *P* remains oxidized while component *b* is reduced. In other words, the reduction of *P*, like that of cytochromes *a* and *c*, is inhibited by antimycin *A*.

(7) The positions of the *c* band in a heart-muscle preparation containing 1 m*M* cyanide and reduced with either 10 m*M* potassium ferrocyanide or a 10 m*M* mixture ferrocyanide/ferricyanide = 70 were at 551 and 550 mμ, respectively. Since cytochrome *b* remained completely oxidized in both cases, these results indicate that the oxidation-reduction potential of *P* lies between those of cytochromes *b* and *c*.

(8) The main properties of *P* can thus be enumerated as follows. (i) It is thermolabile. (ii) It can undergo oxidoreduction. (iii) It can be reduced in the heart-muscle preparation with those reagents which also reduce the cytochrome *c* of the preparation, for example, ascorbic acid, cysteine, sodium succinate and DPNH. (iv) Its reduction by succinate or DPNH is inhibited by antimycin *A*. (v) Its oxidation is catalysed by the cytochrome oxidase system; the compound is therefore not autoxidizable. (vi) It does not appear to react either with cyanide or with carbon monoxide. (vii) Its oxidation-reduction potential lies between those of cytochromes *b* and *c*. (viii) In the oxidized state it has a diffuse absorption spectrum, whereas in the reduced state it must show a strong absorption band lying between the α-bands of cytochromes *b* and *c* and close enough to the latter to shift its apparent maximum from 550 to ~ 552 mμ (Fig. 2). These points suggest that *P* is a thermolabile, non-autoxidizable, antimycin-sensitive cytochrome component with absorption bands in the reduced state lying near those of cytochrome *c*. Like other components of cytochrome, it forms an integral part of the electron transfer chain between activated substrate molecules and molecular oxygen.

Identity of the Pigment responsible for the Shift in the *c*-Band with Cytochrome *e*

A component of cytochrome which exhibits the properties enumerated above is cytochrome *e*, which we discovered during spectroscopic examination of heart-muscle preparations, and of suspensions of different cells, at the temperature of liquid air[21,22].

The success of such experiments at liquid-air temperature (− 190°) depends upon the presence of glycerol in the suspending medium and upon the use of a low-dispersion (direct-vision) spectroscope. When the glycerol concentration exceeds 55 per cent (v/v) the suspension freezes to a translucent glass, while the absorption bands of pigments in the suspension become very sharp and move towards the blue end of the spectrum. Furthermore, groups of bands that cannot be resolved at room temperature become distinctly separate and may themselves show additional fine structure. When the glycerol concentration is 48–50 per cent, further band modifications can be observed. On rapid cooling to − 190° such suspensions freeze to a glass and show the same band-sharpening as was observed with higher proportions of glycerol. When these frozen samples are allowed to warm up slowly they devitrify to a microcrystalline mass which, after re-cooling in liquid air, shows the bands not only sharpened and shifted to lower wave-lengths but also very markedly intensified. Under these conditions a much lower concentration of material is required, but the devitrified mass, being opaque, can be studied only by means of a very low dispersion spectroscope (for example, microspectroscope or hand spectroscope) together with a powerful source of light.

Both methods of cooling have been applied to the study of cytochromes. Spectroscopic examination at low temperatures of the heart-muscle preparation reduced with succinate or sodium dithionite shows the recognized cytochrome components with very sharp bands displaced 2–3 mμ towards the blue. Thus the α-bands of cytochromes *a*, *b* and *c* now lie at about 600, 560 and 548 mμ, respectively. More-

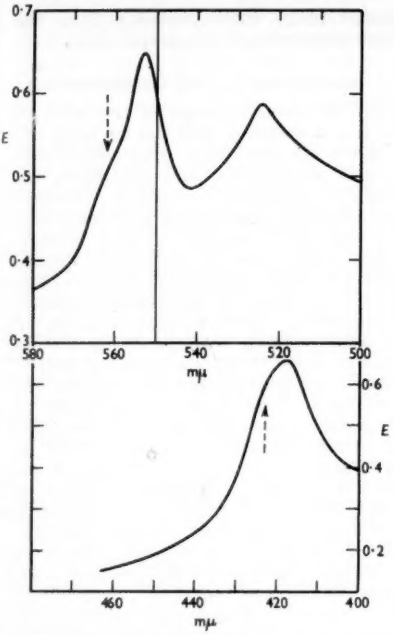

Fig. 3. Absorption spectrum of cytochrome c_1 (= cytochrome *e*) (reduced by sodium dithionite in presence of 0·4 per cent sodium cholate at *p*H 7·3). Upper curve: 2 cm. cuvette. Lower curve: 0·5 cm. cuvette. Shoulders to α- and γ-bands (arrows) represent residual cytochrome *b*

over, the space between the *b*- and *c*-bands becomes clearer and a very sharp band appears at about 551–552 mμ. As the temperature rises, this band disappears rapidly—well before bands *b* and *c* begin to lose much of their acquired sharpness. This and other similar observations lead us to believe that −190° is near the upper limit of a range of temperatures within which more dramatic changes of already sharpened bands would be observed. It can readily be shown that the sharp band at 551–552 mμ, observed at low temperatures, belongs to the component which we called cytochrome *e* and is not an additional peak in the sharpened absorption spectra of cytochromes *b* or *c*. Thus this band fails to appear on cooling a heart-muscle preparation in which only one of the cytochromes, either *b* or *c*, is present in the reduced state. The '*c* only' spectrum was obtained by heat treatment and reduction with sodium dithionite, while the '*b* only' spectrum was obtained by aerating heart-muscle preparation in presence of succinate and antimycin *A*.

As judged by the wave-length of the *c*-band in a variety of cells and tissue preparations, the distribution of cytochrome *e* is very wide. Since cooling to liquid-air temperature shifts the positions of absorption bands 2–3 mμ towards the short-wave end of the spectrum, the position of the α-band of cytochrome *e* at room temperature should be at 553–554 mμ. By applying to a horse-heart muscle extract a modification of the method used by Smith and Stotz[23] for extracting cytochrome oxidase from pig heart we have been able to obtain a clear solution of cytochrome *e* which shows the absorption maxima α-553, β-524, γ-418 mμ. As will be shown later, this compound is identical with the previously described cytochrome c_1. This solution is free from cytochrome *c* and contains only traces of cytochromes *a* and *b* (Fig. 3). Its absorption spectrum is unchanged by treatment with carbon monoxide.

Limits to Resolvability of Groups of Absorption Bands

The question that now arises is whether the α-band of cytochrome *e*, lying in the region of 554 mμ between those of cytochrome *b* (563 mμ) and cytochrome *c* (550 mμ), should be detectable spectrophotometrically in a heart-muscle preparation.

Three possibilities can be considered. Thus the *e*-band might form a distinct maximum in the absorption curve, it might form a shoulder to the *b*- or *c*-bands, or it might fuse with the closely situated *c*-band to give a virtually symmetrical band with a peak at an intermediate wave-length. We shall assume that the α-bands of cytochromes *b* and *e* are of the same shape as that of cytochrome *c* and then consider to what extent the three bands would be resolvable if their relative heights were varied and if the position of the *e* maximum were varied over the range 553–555 mμ.

Fig. 4 shows four such absorption curves with peaks at 563 (*B*), 554 (*E′*), 553 (*E*) and 550 mμ (*C*), corresponding to the α-bands of cytochrome *b*, cytochrome *e* (two alternative positions) and cytochrome *c*. In Fig. 5 are shown curves obtained by summation of the curves in Fig. 4 as follows:

$$l = B + E + C \qquad l' = B + E' + C$$
$$m = B + 0{\cdot}5\,E + C \qquad m' = B + 0{\cdot}5\,E' + C$$
$$n = 1{\cdot}5\,B + 0{\cdot}5\,E + C \qquad n' = 1{\cdot}5\,B + 0{\cdot}5\,E' + C$$

The upper set of curves in Fig. 5 shows that a symmetrical '*c*-band' can be expected when the heights of the individual bands *C* and *E′* are equal (*l′*), but that a shoulder appears at about 554 mμ when the concentration of *E′* is reduced (*m′*. *n′*). Since the original spectroscopic observations on cytochrome *e* indicated that its concentration in heart-muscle preparation is less than that of cytochrome *c*[21], the absence of any shoulder to the *c*-band in spectrophotometric curves of heart-muscle preparations would suggest that the α-band of cytochrome *e* is less than 4 mμ from the α-band of cytochrome *c*. If a similar summation of α-bands is made on the basis of an *E′* maximum at 555 mμ, the *c*-bands of all three curves are very asymmetrical. Curves *l*, *m*, *n*, which are calculated from an *E*-band at 553 mμ,

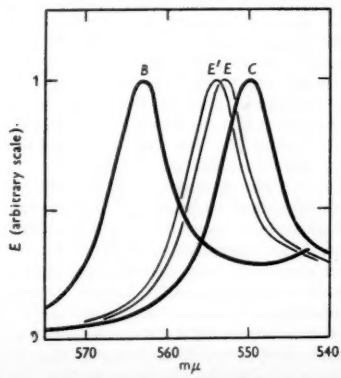

Fig. 4. α-Band of cytochrome *c* (*C*) together with the same band reproduced with maxima at 563, 554 and 553 mμ (*B*, *E′*, *E*)

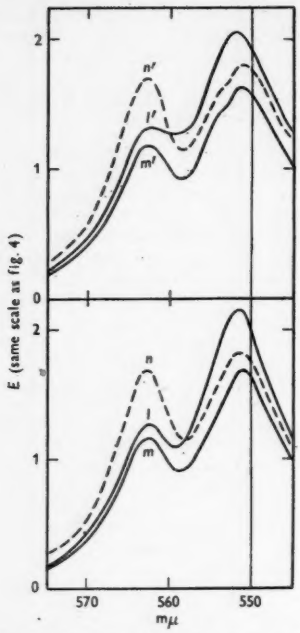

Fig. 5. Curves obtained by summation of curves in Fig. 4 as described in the text. Band peaks: *l*, 551·7; *m*, 551·0; *n*, 551·5 mμ

differ from *l'*, *m'*, *n'* mainly in the absence of shoulders to the *c*-bands. On the basis of experiments to be described elsewhere, the $B : E : C$ ratio represented in summation by curve *n* is considered to approximate to that in a normal heart-muscle preparation, and the wave-length of maximum extinction in this curve (551·5 mμ) agrees within experimental error with the wave-length found for heart-muscle preparation (551·7 mμ). Furthermore, the difference between the *c*-band maxima of *n* and *m* indicates that the *b*-band can influence the position of a maximum due to the fused bands of cytochromes *c* and *e*. This shift can be demonstrated experimentally with the cytochrome *c* - deficient heart-muscle preparation (Fig. 6). The difference spectrum *x* (heart-muscle preparation reduced with succinate *minus* oxidized preparation) shows the α-peak of cytochrome *b* at 562·5 and that of cytochrome *e* at 553·7 mμ. When succinate is replaced by ascorbate (*y*), cytochrome *b* is not reduced and the *e*-maximum now appears at 552·8 mμ, which is essentially identical with the 553 mμ maximum found for isolated cytochrome *e* (Fig. 3). (As stated above, the positions of band maxima could be determined to within 0·3 mμ.) The effect of liquid-air temperature is thus to shift the position of the *e*-band in the heart-muscle preparation from 554 to 552 mμ. An examination of isolated soluble cytochrome *e* (= cytochrome c_1) revealed a similar shift from 553 to 551 mμ. The outstanding difference between the summation curves of Fig. 5 and those obtained from the heart-muscle preparation lies in the more pronounced minimum between the *b*- and *c*-bands of the former. While the virtual absence of a minimum in heart-muscle preparation curves (see Fig. 2, (i)) may be the result of absorption by a so far unidentified pigment or of a minor contribution from cytochrome *a*, we hope to show, in a later publication, that the discrepancy arises more probably from the light-scattering properties of the preparation.

Cytochrome b_5 and Cytochrome e

Already at an early stage of the work on cytochrome it was recorded that the fat body of blowfly larvæ shows an absorption spectrum composed of three bands at 603, 558 and 524 mμ[24]. Thus the components *b* and *c* are replaced in this instance by a single component showing a protohæmochromogen type of absorption spectrum (α-558, β-524 mμ). A component with a similar absorption spectrum was later found by Sanborn and Williams[25] to be generally distributed in tissues of the *Cecropia* silkworm and was described by them as cytochrome *x*. Another very similar pigment with bands at 557, 527 and 424 mμ was found by Strittmatter and Ball[16,17] to be the main cytochrome component of rat-liver microsome fractions. This pigment was probably responsible for masking the α-bands of cytochromes *b* and *c* in our earlier cell-free preparations from liver and kidney[26], and, in fact, by modifying our procedure in such a way that the microsome fraction would be discarded, Slater[8] was able to obtain kidney preparations which showed clear *b*- and *c*-bands. More recently, the pigment from *Cecropia* silkworm midgut, under the name of cytochrome b_5, was re-investigated by Pappenheimer and Williams[27]. According to these authors, "cytochrome b_5 probably accounts for much of the cyanide-, carbon monoxide-, and antimycin-resistant DPNH oxidation, not only in the insect, but also in plant and animal tissues as well". Chance and Pappenheimer[28], who believed they could identify cytochrome b_5 with cytochrome *e*, wrote, "The clear absorption bands of cytochrome b_5 as measured by the recording spectrophotometer are in considerable contrast to the wide, indistinct band that is seen in the microspectroscope, on the basis of which Keilin and Hartree identified the pigment as a special cytochrome *e*. Thus the peculiar appearance of the

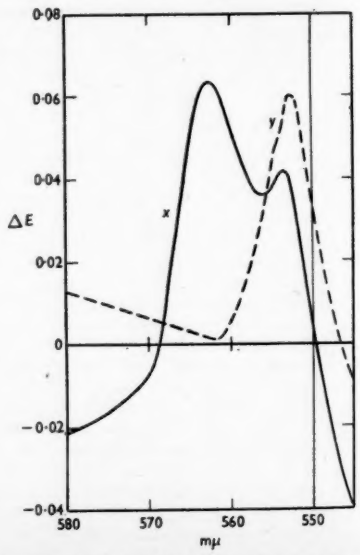

Fig. 6. Difference spectra of cytochrome *c* - deficient heart-muscle preparation. *x*: Preparation + succinate *minus* untreated preparation. *y*: Preparation + ascorbate *minus* untreated preparation

α-band of this pigment in the microspectroscope should no longer be a bar to its identification with the cytochrome *b* family in view of the clear cut band observed in our recordings". This very misleading statement raises a number of points which call for criticism.

(1) Cytochrome *e* was observed by us in cells, tissues and cell-free preparations only when they were cooled to liquid-air temperature, and under these conditions we described the α-band, as seen with a microspectroscope, not as wide and indistinct but as exceptionally sharp[21]. In fact, as we have shown, it is the band sharpening at low temperatures which makes possible the resolution of bands as close together as those of cytochromes *c* and *e*.

(2) Contrary to the view developed in the above quotation, it is generally recognized that a band which appears wide and indistinct when examined with a low-dispersion spectroscope will appear still less distinct when recorded with a spectrophotometer which, of necessity, must have a much higher dispersion. As an example, we may consider the shoulder at 563 mμ in Fig. 3, which appears as a distinct band when examined with a microspectroscope. The same applies to the α-band of ferricytochrome *c* or other parahæmatin compounds which can be seen as a separate band with a microspectroscope but which appears as a scarcely perceptible irregularity on the long-wave side of the β-band in a spectrophotometric curve.

(3) The view as to the identity of cytochromes b_5 and *e* put forward by Chance and Pappenheimer[28] is not supported by a systematic comparison of these two components. Thus it was previously shown that cytochrome b_5 is autoxidizable, that its reduction by the succinic dehydrogenase system is very slow, that its reduction by DPNH is rapid but not affected by antimycin *A* and that its α-band lies at 558 mμ. We have now shown that cytochrome *e* is not autoxidizable, that its reduction by the above systems is rapid and inhibited by antimycin *A*, and that its α-band lies at 553 mμ. Moreover, where structural elements of cytoplasm could be separated, cytochrome *e*, like cytochromes *a*, *b* and *c*, was found to be localized within mitochondria, whereas cytochrome b_5 was found associated with the microsomes. While cytochrome b_5 shows a marked resemblance to other components of the *b*-group, cytochrome *e*, as will be seen, is more appropriately classified with cytochrome *c*.

Identity of Cytochrome e with Cytochrome c_1

If a cell-free ox heart-muscle suspension is washed with acetate buffer (*p*H 4·6) and phosphate buffer (*p*H 7·5) and then treated with succinate and cyanide it shows, according to Yakushiji and Okunuki[29,30], in addition to the absorption bands *a* and *b*, a band at 552 mμ. They ascribed this band to the presence of a new cytochrome component which they named cytochrome c_1. In a normal heart-muscle preparation they could not distinguish this component from cytochrome *c*. Cytochrome c_1 was separated by them from other components of cytochrome by extracting a heart-muscle preparation with sodium cholate, fractionally precipitating the extract with ammonium sulphate and dissolving the appropriate fraction in phosphate buffer *p*H 7·3. The main properties of cytochrome c_1 as given by these workers can be summarized as follows. (1) In the reduced state it shows three absorption bands: α-552, β-522 and γ-416 mμ; on oxidation the γ-band is shifted to 410 mμ. (2) It is not autoxidizable, but is rapidly oxidized by ferricytochrome *c* or by a mixture of 99·25 per cent potassium ferrocyanide and 0·75 per cent potassium ferricyanide, which indicates that its oxidation-reduction potential lies between those of cytochrome *b* and cytochrome *c*. (3) On treating this component with pyridine and sodium dithionite, its α-band shifts from 552 to 550 mμ, which is the position of the α-band of cytochrome *c*. (4) A similar compound can be obtained from heart muscle of other mammals, *Acetobacter pasteurianum*, baker's yeast, a red alga *Porphyra tenera*, and from other organisms.

The position of cytochrome c_1 in the electron transfer chain was represented by Yakushiji and Okunuki as follows:

$$O_2\text{—Cytochrome oxidase—}c \leftarrow c_1 \leftarrow b\text{—succinic dehydrogenase}$$
$$\Updownarrow \swarrow \quad a$$

Our suggestion[7] as to the possible identity of cytochrome c_1 with the BAL (2 : 3-dimercaptopropanol)-sensitive factor[31], which forms an important link between cytochrome *b* and cytochrome *c*, was not confirmed by Slater[32]. He repeated Yakushiji and Okunuki's experiments and also obtained their type of preparation, with the band at 552 mμ, from a heart-muscle preparation treated with BAL, which irreversibly destroys the 'factor'. We have re-examined this BAL-treated heart-muscle preparation and conclude that, since the wave-length of its *c*-band (551·8 mμ) is virtually identical with that shown by a normal preparation, the BAL treatment does not destroy the component responsible for shifting the α-band of cytochrome *c* from 550 to 552 mμ. Furthermore, Slater[32] could find no clear evidence in support of the existence of cytochrome c_1, and he explained the position of the absorption band at 552 mμ as being due to displacement of the α-band of cytochrome *c* by the presence of a band due to the denatured protein protohæmochromogen in such preparations.

Having repeated the experiments of Yakushiji and Okunuki and, by a similar method, obtained their cytochrome c_1 (Fig. 3), we were able to corroborate their main observations. The similarity in properties of cytochromes c_1 and *e* described above strongly supports the view that these two components are identical. We have reached this conclusion despite the fact that the band positions given for cytochrome c_1 (α-552, β-522, γ-416 mμ) do not agree closely with those that we have found for cytochrome *e* (α-553, β-524, γ-418 mμ). These differences are, however, very small and may be due either to the presence in their material of a small amount of cytochrome *c* or to the fact that their spectrophotometric equipment lacked the precision of modern photoelectric instruments. While it is true that in attempting to follow the incompletely described method for preparation of cytochrome c_1 we obtained material containing protein protohæmochromogen, we do not believe that its presence could bring about a shift of the α-band of cytochrome *c*. Our analysis of the mutual interference to be expected from neighbouring absorption bands can be extended to show that the α-band of such a hæmochromogen, which would lie at about 558 mμ, could not bring about an apparent shift of 2 mμ in the position of a markedly stronger α-band of cytochrome *c*. On treating a solution of cytochrome c_1 with sodium hydroxide (0·1 *N*), pyridine and sodium dithionite,

its α-band shifts to 550·4 mμ and the absorption spectrum is then indistinguishable from that of cytochrome *c* treated in the same way. Similar changes in the α-band of cytochrome c_1 are obtained when a cytochrome *c* - deficient heart-muscle preparation is warmed to 70° and reduced with sodium dithionite. It is conceivable that cytochrome c_1 occupies an intermediate position between cytochrome *c* and a more primitive protohæmochromogen precursor. However, problems involving the relationship between structure and absorption spectra of hæmoproteins must await solution until the reactions of hæms and hæmoproteins with different substances are better understood[23]. Since cytochromes c_1 and *e* appear to be identical, the term cytochrome *e*, proposed in 1949, should be replaced by cytochrome c_1, which was introduced in 1940. Furthermore, the designation c_1 more clearly indicates the relationship of this component with cytochrome *c*.

Summary and Conclusions

(1) It is known that the extracted, soluble or exogenous cytochrome *c* differs in some of its properties from the endogenous form present within cells or cell-free preparations. That these differences do not reflect any marked change in the structure of cytochrome *c* during its extraction and purification is indicated by the ease with which extracted cytochrome *c* can be re-incorporated into cytochrome *c*-deficient heart-muscle preparations, after which it appears to re-acquire the properties of the endogenous pigment originally present in the preparation.

(2) The difference in the absorption spectra of these two forms of cytochrome *c* in the reduced state is of special interest since it has now been shown to depend upon the presence within cells or cell-free heart-muscle preparations of another component of cytochrome the α-band of which fuses with that of cytochrome *c* (550 mμ), forming a single band with a maximum at 552 mμ.

(3) This additional component is the cytochrome c_1 of Yakushiji and Okunuki[19,20], which we now identify with a component formerly described by us as cytochrome *e* [21].

(4) The evidence for the existence of cytochrome c_1 (= cytochrome *e*), which is based upon the study of absorption spectra at low temperatures, the displacement of the α-band of cytochrome *c* when it forms part of a complete cytochrome system and the isolation of component c_1 virtually free from other cytochrome components, can be summarized as follows.

(i) The α-band of cytochrome c_1 can be easily seen together with all other components of the cytochrome system in cells and cell-free heart-muscle preparations suspended in aqueous glycerol and cooled to the temperature of liquid air. It is the great sharpening of absorption bands at very low temperatures that resolves the fused α-bands of cytochromes *c* and c_1 into two distinct bands with peaks about 3 mμ apart.

(ii) The α-band of cytochrome c_1 can be seen at 553–554 mμ in a heart-muscle preparation made deficient in cytochrome *c* and reduced with ascorbic acid.

(iii) In an optical mixture of the reduced cytochrome c - deficient heart-muscle preparation and reduced soluble cytochrome *c*, the α-band of the latter is displaced from 550 to 552 mμ.

(iv) On the other hand, the α-band of endogenous cytochrome *c* (which represents a mixture of those of cytochrome *c* and cytochrome c_1) is shifted from 552 to 550 mμ when cytochrome c_1 is either denatured or oxidized.

(v) A preparation of cytochrome c_1, rendered soluble by means of sodium cholate, has been isolated from heart muscle. It shows absorption maxima at 553 (α), 524 (β) and 418 (γ) mμ.

(5) It has been shown that two absorption bands even as sharp as the α-band of cytochrome *c* cannot be resolved spectrophotometrically if their maxima lie 4 mμ or less apart. However, two such bands with maxima only 3 mμ apart can be easily resolved if the bands are made much sharper by cooling the material to the temperature of liquid air.

(6) Contrary to the view put forward by some workers[28], cytochrome c_1 (= cytochrome *e*) is not identical with cytochrome b_3. These two components show marked differences in their localization within cells, in their absorption spectra, in their reactions with biological reducing systems in presence and in absence of antimycin *A*, and in their reactions with oxygen.

(7) Cytochrome c_1, like cytochrome *c*, is not autoxidizable, and its reduction by the succinic dehydrogenase system or by DPNH (reduced coenzyme I) is inhibited by narcotics and by antimycin *A*. It reacts neither with carbon monoxide nor with cyanide. Unlike cytochrome *c*, but like other components of cytochrome, it is thermolabile and more intimately linked with structural elements of the cell.

(8) Cytochrome c_1 (= cytochrome *e*) is a widely distributed component forming an integral part of the intracellular electron transfer chain between activated molecules of substrate and oxygen.

We wish to thank Dr. F. M. Strong for a generous gift of antimycin *A*.

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LETTERS TO THE EDITORS

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Function of the Bower of Bower-birds

THERE exist two widely divergent and irreconcilable theories concerning the nature and function of bower-building in bower-birds (Ptilonorhynchidae). The first, which may be called the traditional view, finds its expression in numerous writings (references in Marshall[1,2]) which describe bower-birds as intelligent and consciously æsthetic (in the human sense of the expressions) in their collection of colourful display-things and in bower-building. This view involves also the stated belief that bowers are built for recreational purposes and are little concerned with reproductive processes, even though the latter may have accounted for the origin of display in the early history of the species.

The second view is that the bower and display-ground form the centrepiece of the male bird's territory, and that to it is attracted a female to which the male displays (sometimes for several weeks) until the environment, and next the female's internal sexual processes, come seasonally to a state appropriate for successful reproduction, after which copulation occurs. Thus, the copulation-date, and hence the ultimate timing of the breeding season, is considered to be controlled by environmental factors operating through the exteroceptor organs of the female.

In advancing the latter hypothesis Marshall[2] has written that it is not yet known what are the events that "cause sudden transference of the physical attention of the male from his display-things to the . . . female which has been waiting alongside for so many weeks".

Observations made by me in the Cordeaux River area, south-eastern New South Wales, on October 2, 1954, perhaps supply these missing data.

A blue-black male satin bower-bird (*Ptilonorhynchus violaceus*) came to its highly decorated display-ground, renovated the bower, painted its walls (with charcoal mixed with saliva) and then flew to a tall *Acacia* tree near by, where he repeatedly produced a long-drawn territorial whistle for about half an hour. A female now came to the bower and, after moving around, went to the central avenue at the entrance facing the display-ground. Here she stood. The male then flew down to the display-ground and began to display (Fig. 1). After a few minutes the female

Fig. 1

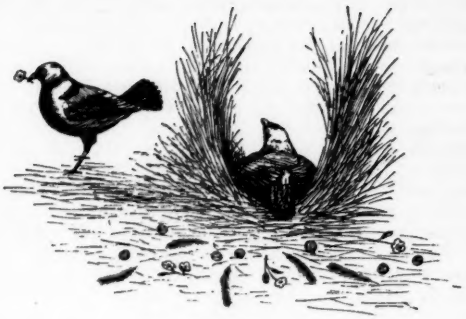

Fig. 2

assumed the peculiar squatting or flattened crouching attitude, shown approximately in Fig. 2. The male now intensified his performance. The female maintained the crouching position for no less than ten minutes, her only appreciable motion being a rotation of the head as her gaze followed the actions of the male. The male displayed back and forth, holding blue flowers in his beak. Then he moved quickly to the front entrance of the bower where copulation occurred, considerably disordering the bower. The male next departed, and then the female disappeared. Twenty minutes later the male returned and renovated his damaged bower.

Although several observers have reported the presence of a single female *Ptilonorhynchus* standing passively watching the displaying male, this appears to be the first occasion on which a female has been seen to strike a special attitude, and the first time, moreover, on which copulation has been observed, although it has been reported at the bower of the spotted bower-bird (*Chlamydera maculata*)[3]. It seems reasonable to suppose that it was the prolonged and peculiar crouching attitude adopted by the female at the bower that released in the male the drive towards coition.

No evidence that polygamy occurs in the above species was obtained. Only one female was seen near the bower; and I have never found more than one nest near a display territory.

A longer account of the present and allied observations will be published in *The Emu*, the journal of the Royal Australasian Ornithologists' Union.

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Aphid Chromosomes

DURING the early years of this century several workers, notably Morgan[1] and Stevens[2], became interested in the chromosomes of Aphididae, mainly in connexion with their studies on the behaviour of the sex chromosomes and on the phenomenon of parthenogenesis. Shinji[3] wrote on the evolutional significance of the chromosomes of the Aphididae. He investigated some thirty-seven species of American aphids, of which the somatic chromosome numbers ranged from six to thirty-eight, and claimed that the

number of chromosomes and the physical characteristics of a species are so closely correlated that the 'evolutional scale' of any aphid can safely be judged from its chromosome number.

Unfortunately, in view of the confused state of systematics and nomenclature of aphids at that time, together with the complete lack of descriptions, no reliance can be placed on Shinji's identifications, even though his general conclusions may retain some validity.

Owing to the recent advances in the study of aphid systematics, a general survey of chromosome numbers on the lines attempted by Shinji, but with reliably identified species, is now possible and is being conducted. This should provide interesting information on the evolution of Aphididae, and it is hoped also that new light will be shed on some of the problems connected with speciation, hybridization, the initiation of wing production in the viviparous generations, and the production of the sexual forms.

For several reasons it has been found best to work with diploid material. Though testis material would provide large numbers of dividing nuclei in suitable stages, and the counting of haploid numbers would be easier, in practice it is impossible to identify with sufficient certainty the naturally occurring male aphids in the early instars which alone are of use. Spermatogenesis is completed in the nymphal stages, and adult males contain only mature sperms. The use of males is further limited by the short period of the year during which they are obtainable. Hence, smears are made of the body contents of viviparous parthenogenetic females. These females are readily identifiable and, in addition to being available in large numbers from spring to autumn, can in many cases be cultured indoors during the colder months.

The advanced embryos removed from mature viviparous females themselves already contain parthenogenetic ova and embryos in the early stages of segmentation, and it is in these early cleavage divisions that the largest chromosomes are to be found. Even here, however, the average chromosome size during metaphase is only about 1μ, and the diameter of the metaphase plate is about 4μ.

Because of the small size and close approximation of these chromosomes, only the very best prophase and metaphase figures can be used for reliable counting and comparison. As such figures are relatively scarce in the preparations, large numbers of smears are necessary. Temporary preparations, though occasionally useful, are not suitable for mass production and lengthy examination, so permanent slides are the rule. Fixation and staining must be of high quality, and though many techniques have been tried, the best results have been obtained from permanent smears fixed in osmic acid and stained with crystal violet or by the Feulgen method.

The somatic chromosome numbers of the species of aphids so far investigated are multiples of four; for example, in *Aphis fabae* Scop., *Aphis rumicis* L., *Aphis viburni* Scop., and *Acyrthosiphon pisum* (Harris), $2n = 8$; in *Brachycaudus prunicola* Kltb., *Hyperomyzus lactucae* L., *Myzus persicae* (Sulz.) and *Pachypapella reaumuri* Kltb., $2n = 12$; and in *Brevicoryne brassicae* L., $2n = 16$.

Although the examples quoted are insufficient to show any general trends, it is obvious that the possession of the same chromosome numbers is not necessarily an indication either of close morphological relationship or of 'evolutional' affinity, despite Shinji's assertion to the contrary.

On the other hand, it appears that very closely allied forms, as, for example, members of the *Aphis fabae* 'complex', a few of which have been investigated, do have the same chromosome numbers. Further comparison of such forms must be conducted on the basis of the relative sizes and shapes of individual chromosomes.

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Regeneration of the Filtrable Forms of *Salmonella enteritidis* in Media containing Blood Plasma (Fibrin Structure)

The experiments to be described were conducted with the purpose of attaining a more extensive regeneration of filtrable forms by modifying the technique. In analogy with the use of blood plasma in tissue cultures, we also added blood plasma to media for regeneration, as it was thought that granules capable of regeneration would be adsorbed on the submicroscopic network of fibrin, creating thereby more favourable conditions for assimilation processes than would be brought about had the granules settled to the bottom of the tubes.

In these experiments 'regeneration' was understood to mean growth through intermediate forms, after a period longer than 72 hours in media enriched with native proteins, as compared to the sterility of the control media.

There were three series in which filtrable forms were obtained partly by ageing of the cultures and partly by exposure to a sublethal dose of penicillin[1]. Filtration was through Seitz *S* filters at a negative pressure of 10–15 mm. mercury for about 10–15 min.

One part of the filtrate was then centrifuged at 9,600 r.p.m. for 45 min. in an angle centrifuge (Vifug Stockholm, type *B*). This was done for the following reasons: (1) to obtain an inoculum containing an unusually high number of filtrable forms per unit volume; (2) to make the sterility tests even more

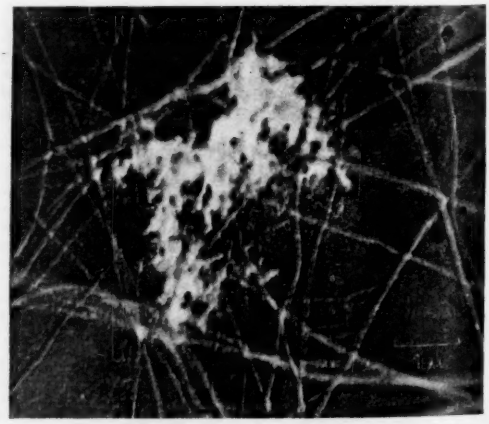

Fig. 1. Granules from the filtrate on the fibrin network. (The electron micrograph was taken by M. D. Egyessy, of the Electron-Microscope Laboratory, Hungarian Academy of Sciences, to whom we express our thanks)

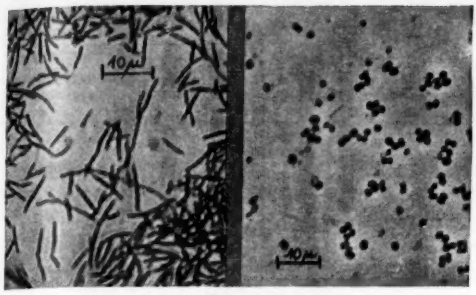

Fig. 2. Atypical *Salmonella* regenerated from filtrate

Fig. 3. Polymorphous culture of cocci grown from filtrate

valuable and convincing. It is obvious that even if only a few bacteria pass through the filter, they will be easily detectable in the sediment; (3) to obtain a preparation which is pure and concentrated for electron microscopic studies.

The inocula were: the filtrate, the sediment and the supernatant fluid obtained by centrifugation. Each of these was inoculated into the following media: (*a*) serum broth; (*b*) serum broth containing approximately 5 per cent chicken plasma; (*c*) commonly used media for sterility tests aiming at detecting the eventual presence of *Salmonellae*.

In none of the control media could we demonstrate the growth of *Salmonella* or any related organism.

To avoid subsequent contamination, the closed tubes were kept in an incubator at 37° C. and remained unopened until cloudiness or formation of a deposit visible to the naked eye could be seen in them.

Irrespective of the method used for inducing filtrable forms (ageing or penicillin treatment), the media containing blood plasma proved to be superior to serum broth so far as the reversion of filtrable forms to microscopically visible forms was concerned. In media enriched with plasma, regeneration was more marked, and the cultures grown in them resembled the initial strain more closely than those grown in serum broth. Moreover, complete reversion to the initial strain resulted exclusively in the serum broth containing plasma in the above experiments. The reverted strains were identified on the basis of morphological appearance, fermentation and serological (agglutination) tests and mouse pathogenicity.

Regeneration took place in thirteen of a total of fifteen plasma cultures; of these, complete reversion occurred in two cases; bacillary cultures differing mainly serologically and pathologically from the original *Salmonella* strain arose in six cases; polymorphous culture consisting of coccoids and rods in one case; coccoid cultures in four cases and only in six of a total of fifteen serum broth cultures (yielding all coccoid cultures).

Further experiments are necessary to elucidate whether the role of fibrin in the process of regeneration as a network is a purely mechanical one or whether it has biochemical implications as well.

As in similar experiments by other workers, in the series reported upon here, evidence was obtained to show that bacterial life-cycles exist and that bacteria are extremely variable. It appears to be beyond doubt that in many cases the transformation of bacteria will take place through filtrable forms.

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Manganese Requirement and Carbon Source in *Chlorella*

Photosynthesis of unicellular green algae (*Chlorella*[1], *Ankistrodesmus*[2], *Scenedesmus*[2]) requires the presence of small quantities of the micronutrient manganese (Mn^{2+}). Manganese-deficient cells show a much-reduced photosynthesis, which can be rapidly brought to normal by addition of manganese (short-term recovery effect). This effect of manganese has been shown to occur both in strong and in weak light[2,3].

During a comparative examination of the mineral requirements of auto-, hetero- and mixo-trophically grown *Chlorella vulgaris*[4] the role of manganese has also been followed. As Fig. 1 shows, manganese deficiency (manganese being omitted from the solution, which was not specially purified) has no influence upon growth in green heterotrophic culture in darkness (1 per cent glucose, air + 3 per cent carbon dioxide); however, cells of this culture show an inhibited photosynthesis in light and give the well-known recovery effect. Cells cultivated autotrophically and mixotrophically (glucose + light) are strongly inhibited in their growth by manganese deficiency. In mixotrophic cultures the glucose is not completely used up. If transferred to darkness, the manganese-deficient mixotrophic cells continue glucose consumption and growth. Conversely, growth and glucose consumption are stopped when heterotrophic cells from manganese-deficient cultures are transferred from darkness into sufficiently strong

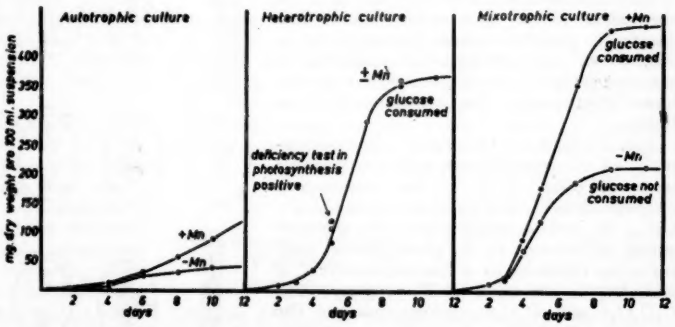

Fig. 1. Growth of *Chlorella* in an inorganic medium (autotrophic), with 0·5 per cent glucose in darkness (heterotrophic), and 0·5 per cent glucose in light (mixotrophic) ± added Mn^{++} (10^{-6} m., closed or open circles). Glucose content of the solution has been tested with aniline phthalate (ref. 8). Heterotrophic cells from the culture show the typical photosynthetic symptoms of manganese deficiency, when transferred to light at the time marked by the arrow

light. The question why mixotrophically grown manganese-deficient cells in the light are prevented from adopting the heterotrophic form of nutrition is being explored at present. The available data suggest a photometabolism of glucose, which is different from that in darkness, and which is linked to the photosynthetic apparatus of the cell[5]. Other results obtained with normal and deficient cells point in the same direction[4].

Whether the photometabolism of glucose can be compared with the consumption of organic material by green and purple bacteria[6] during anaerobic photosynthesis must be further studied. *Chlorella*, which has been grown anaerobically without carbon dioxide but with glucose in the light[7], proves, according to our observations, to have the same requirement of manganese as autotrophic and mixotrophic cultures. Manganese deficiency manifests itself in all the cases examined, where the cells make use of their photosynthetic apparatus.

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Genetics of Endosperm

In *Trillium grandiflorum* and other species of the same genus, cold treatment reveals differences between homologous chromosomes with regard to number and/or length of heterochromatic segments[1]. In our experiments, differences have been found in the *B*-, *C*- and *E*-chromosomes (Figs. 1, 2*A*). According to the number and length of these segments, the following types of chromosomes have been distinguished: B_1, $B_{\frac{1}{4}}$, C_1, C_2, E_2 and E_3 (where the suffixes give the number or length of the heterochromatic regions).

In order to learn how eu- and heterochromatic blocks are carried over into daughter plants, crosses between individuals of *T. grandiflorum* differing in the structure of homologous chromosomes have been made (for example, $C_1C_2 \times C_1C_1$).

Fig. 3 illustrates the embryo sac development of *T. grandiflorum* and the possible ways of distribution of the homologous chromosomes C_1 and C_2 in the cross $C_1C_2 \times C_1C_1$. It will be evident that the chromosomal differences in *T. grandiflorum* may serve as markers in a 'tetrad analysis' if endosperms are used as F_1-progeny. All $C_1C_1C_1$- and $C_1C_2C_2$-endosperms are the product of a first-division segregation, whereas the $C_1C_1C_2$-endosperms arise as the result of a second-division segregation of the heterochromatic region (Fig. 2*B*).

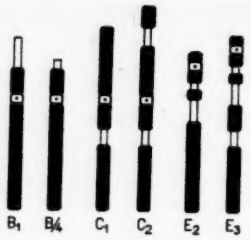

Fig. 1. Chromosomes of *Trillium grandiflorum* (euchromatin in black, heterochromatin in white; centromere region dotted). × 5,000

Fig. 2. Chromosomes of *Trillium grandiflorum*, × 800. (*A*) Metaphase from a cold-treated root tip, (*B*) metaphase from a cold-treated endosperm of the cross $C_1C_2 \times C_1C_1$ ($C_1C_1C_2$ indicating second-division segregation)

In our experiments, all three types of endosperm occurred (see Table 1). In agreement with expectation, the ratio of the two types of first-division segregation, $C_1C_1C_1$ and $C_1C_2C_2$, was found to be around 1 : 1. The frequencies of second-division segregation, of type $C_1C_1C_2$, proved to be fairly high ($x = 37$, $y = 28$, $z = 42$). Mather[2] has shown that in the absence of interference, the frequency of second-division segregation approaches a random value of 2/3 when the distance between the centromere and a given locus becomes large. In two cases, our experimental data do not deviate significantly from this theoretical value ($P_x < 0{\cdot}2$, $P_y < 0{\cdot}3$). In the third case, however, the observed proportion of second-division segregation is significantly higher

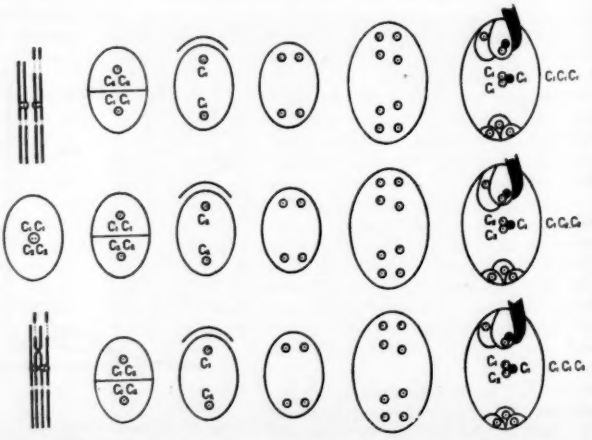

Fig. 3. Illustration of embryo-sac development in *Trillium grandiflorum* (*Allium*-type), showing distribution of homologous chromosomes (sperm nuclei and pollen tubes shown in black)

Table 1. Distribution of Heteromorphic Chromosome Pairs in Endosperms of *Trillium grandiflorum*

Parent plants and cross	Endosperms			Second division segregation (per cent)
1. $C_1C_2 \times C_1C_1$	$C_1C_1C_1$	$C_1C_1C_2$	$C_1C_2C_2$	
G 3 × G 42	3	15	4	
G 3 × G 4	0	20	3	
G 55 × G 42	6	27	7	
GH 1 × G 19	0	1	1	
GH 2 × G 19	0	4	0	
GH 6 × G 45	1	7	2	
GH13 × G 49	0	4	0	
Total	10	78	17	37
2. $E_1E_2 \times E_1E_2$	$E_1E_1E_2$	$E_1E_1E_2$	$E_1E_2E_2$	
G 40 × G 4	3	8	6	
G 40 × G 23	2	6	0	
G 72 × G 45	4	11	3	
GH 2 × G 19	1	3	0	
GH13 × G 49	0	0	3	
Total	10	28	12	28
3. $B_1B_1^{\frac{1}{2}} \times B_1B_1$	$B_1B_1B_1$	$B_1B_1B_1^{\frac{1}{2}}$	$B_1B_1^{\frac{1}{2}}B_1^{\frac{1}{2}}$	
G 23 × G 36	4	57	7	42

($P_2 < 0{\cdot}01$), suggesting the presence of interference or of localized chiasmata in our material.

This type of tetrad analysis, which is based on the presence of one product of the first meiotic division only, has independently been used by Leupold (personal communication) for determining second-division segregation frequencies in the surviving progeny of monosomic segregants derived from tetraploid yeast strains.

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Influence of the Origin of the Isolate of *Rhizoctonia solani* on its Pathogenicity

The fact which has received most attention in connexion with investigations on the pathogenicity of *Rhizoctonia solani* strains is the influence of the origin of the isolate on its pathogenicity. The results of these investigations are rather contradictory. Thus, Wellman[1], Gram and Webber[2] and others claim that each isolate is most pathogenic to that plant species and its close relations from which it has been obtained. On the other hand, the results reported by Storey[3], Peltier[4], Houston[5], Bosch[6], Linnasalmi[7] and others seem to oppose this theory of specificity.

In the present investigation, *Rhizoctonia* strains isolated from Ashmouny and Giza '30' cotton varieties, tomato, water-melons, *Phaseolus* and *Pisum* damped-off seeds and seedlings were used. The different strains were inoculated separately into sterile soil in the usual way. Seeds of the different plants mentioned above were sown in soils containing each of the *Rhizoctonia* strains after adjusting their moisture content to 60 per cent water-holding capacity. Controls were kept in sterile soil at the same moisture-level. The containers were incubated at two temperature-levels, namely, 9°–15° C. and 21°–37° C., for a period of four weeks, during which emergence, post-emergence damping-off and survival counts were made.

Examination of the results obtained from the high-temperature series showed that: (1) Within the same plant species, for example cotton, isolates obtained from Giza '30' variety showed a striking difference in their pathogenicity from that of Ashmouny. Thus, two isolates obtained from Giza '30' cotton were almost non-pathogenic to tomato and slightly pathogenic to the other hosts. The isolate obtained from Ashmouny cotton, on the other hand, proved to be very pathogenic to the two cotton varieties and *Pisum*. The other three hosts, namely, tomato, *Phaseolus* and water-melon, showed appreciable susceptibility to this isolate. (2) The isolate from water-melon proved to be weakly parasitic, if at all, on the various host plants used. (3) The isolate from *Phaseolus* was very active against water-melon and *Pisum* and moderately active against the rest of the host plants. (4) The isolate from tomato attacked all seedlings of the two cotton varieties and about 60 per cent of the seedlings of *Phaseolus*. On tomato seedlings themselves this isolate proved to be a weak parasite, particularly as a cause of pre-emergence damping-off, although it was quite active as a post-emergence damping-off causal agent. (5) The most active isolate was that of *Pisum*. It destroyed the seedling stands of five host plants completely and the sixth, that is tomato, was badly injured.

The results of the low-temperature series showed that: (1) The pathogenicity of the isolate obtained from Giza '30' cotton, the isolate from Ashmouny cotton and that from water-melon followed, more or less, the same trend as that at high temperature. (2) The isolate from water-melon again proved to be non-pathogenic to the various host plants used. (3) The isolates from tomato, *Phaseolus* and *Pisum* were destructive to all host plants.

The hosts used in this investigation are of very widely separated families of the angiosperms, and yet all, or nearly all, of them were destroyed by several isolates obtained from unrelated plants. This fact supports the view that there is no specificity of the attack of *Rhizoctonia* isolates on the host plants. The facts that the isolate of Ashmouny cotton destroyed the whole stand of *Pisum* seedlings and was only moderately pathogenic at high temperature to *Phaseolus*, which belongs to the same family, and that the isolates of tomato and *Phaseolus* revealed the same effect at both temperature-levels may be taken as circumstantial evidence supporting the view of non-specificity of *Rhizoctonia* isolates.

The results of the present investigation also refute the view that the isolate is usually most active on the plant species from which it has been obtained, since it can be seen from the results of the high-temperature series that the isolates from tomato and *Phaseolus* were more active on other hosts than the respective plants from which they were obtained.

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Apparent Reciprocal Exchange of Characters between the *Mel* and *NWS* Strains of Influenza *A* Virus in the Brain of One-day Old Mice

Evidence has accumulated in the work of Burnet and his colleagues[1,2] that some form of genetic interchange takes place between two strains of influenza virus that have been inoculated into a susceptible host in adequate amounts. However, information about the interaction between the non-neurotropic, *Mel*, and the neurotropic, *NWS*, strains of influenza *A*, which was among the first to be described[1], remained deficient in some important respects.

The recombinant recovered from this system was *N-M* (neuro-*Mel*) virus; but mouse-neuropathogenic *N-M* strains were recovered only from doubly infected mouse brain, not from the infected allantoic cavity of the chick embryo. They were recoverable only after four days had elapsed from the time of intracerebral inoculation[1]. The yield of *N-M* strains from the allantoic cavity was always too small to permit its recovery by direct dilution of the primary product of double infection[3]. No non-pathogenic strain of *WS* serological type was obtained either from the mouse brain or from the allantoic cavity[4]. All this cast some doubt on the mode of origin of *N-M* strains.

In order to investigate these deficiencies, experiments were undertaken to determine how early, after double infection of brain, recombinant strains could be obtained, to find out to what extent neuropathogenicity was transferred at this stage and to search for non-neurotrcpic viruses of the *WS* type which could be regarded as the 'reciprocal recombinants' to *N-M* in the *NWS – Mel* recombination system.

Double intracerebral infection of the one-day old mouse provided a successful method. Such a site of genetic interaction has several disadvantages. The original inoculum is not confined to the site of inoculation[5]; there is no hope of preventing the product of the first cycle of multiplication from being similarly dispersed or from initiating a second reproductive cycle; the cerebral tissue, unlike the allantoic membrane, is heterogeneous and some cells may support the growth of one virus strain better than another. On the other hand, the unadapted *Mel* strain will grow for at least one reproductive cycle[6] and the growth of *NWS* ought to be favoured by this environment.

In spite of these complexities, direct titration at the limit of infectivity of suspensions of brain harvested at various intervals after the inoculation of approximately $10^{7\cdot0}$ ID_{50} of each strain of virus revealed the presence of virus strains which could be regarded as reciprocal recombinants of the two parent strains *Mel* and *NWS*.

Table 1 shows their origin, the time after inoculation at which they were found and the properties by which they are ordinarily distinguished. The numbered fluids were obtained by two successive passages at limiting infective dilution from the original suspension of infected brain, and the properties to which the table refers were tested on freshly harvested fluids prepared from the numbered fluids by one further allantoic passage at the limit of infectivity in eleven-day old chick embryos.

The interesting features of the results are:

(1) Recovery of non-neurotropic virus of the *WS* type at a slightly earlier stage than that at which *N-M*'s were isolated. It is recognizable *in vitro* by some degree of stability against heating at 56° C. for 30 min. and by its lack of sensitivity, when heated, to the inhibiting effect of ovomucin.

(2) *N-M* strains were recovered after 12 hr. In this time it is unlikely that spontaneous mutation and selection by the favourable environment of nervous tissue could account for their origin in such numbers.

(3) The distribution of pathogenicity in the *N-M* strains extended over a wide range, from three strains which were non-pathogenic to the chick embryo on chorio-allantoic inoculation, but which proved lethal intravenously, to two strains which were fully lethal for both the chick embryo and the adult mouse. This distribution at an early stage in the series of reproductive cycles is similar to that of fourth-day fluids and to that obtained for other recombinant systems by Lind and Burnet[7].

(4) The total yield of recombinants as compared with the proportion in the chick allantoic cavity and the recovery of a possible *WS* recombinant suggest that the opportunities for genetic interaction of these two strains may vary from one tissue to another.

Table 1

Fluid No.	Source (mouse brain No.)	Time recovered after infection (hr.)	Titre		Serological type	Indicator phase to ovomucin	Pathogenicity	
			Unheated	Heated 56° C. 30 min.			To chick via chorioallantois	To mouse intracerebral
4,422	358	+18	480	30	*Mel*	+	*P*	*L*
4,579	358	18	40	12	*Mel*	+	*P*	*L*
4,491	358	18	520	55	*Mel*	+	*P*	*P*
4,597	358	18	20	12	*Mel*	+	*P*	*P*
4,564	358	18	240	100	*Mel*	+	*P*	0
4,499	358	18	60	20	*Mel*	+	*P*	0
4,590	358	18	60	25	*Mel*	+	0 (*P*)	0
4,151	341	18	160	80	*Mel*	+	*P*	*P*
4,232	314	12	30	15	*Mel*	+	*P*	*P*
4,185	342	18	300	220	*Mel*	+	0 (*P*)	0
3,891	308	19	40	10	*Mel*	+	0 (*P*)	0
6,205	313	12	140	50	*NWS*	–	0	0
6,185	314	12	800	400	*NWS*	–	0	0
6,411	312	12	280	60	*NWS*	–	0	0
6,610	339	12	300	160	*NWS*	–	0	0
6,582	332	8	320	80	*NWS*	–	0	0
Stock *Mel*			800	800	*Mel*	–	0	0
Stock *NWS*			400	0	*NWS*	+	*P*	*L*

+ = Hæmagglutination inhibited by high dilution of ovomucin; – = hæmagglutination not inhibited by ovomucin; *L* = lethal within 10 days after intracerebral inoculation of $10^{4\cdot5}$ ID_{50}; *P* = producing symptoms, specific either for chick embryo or for mouse; (*P*) = producing symptoms only after intravenous inoculation of chick embryo; 0 = no symptoms or lesions produced.

(5) The demonstration of the indicator phase in heat-sensitive *NWS* will be described elsewhere. This character of *NWS* has only been assumed to exist until now[7].

This work was supported by a grant from the Advisory Committee on Medical Research (Scotland) and will be reported in detail later.

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A New Species of Sporozoan ?

In the course of research on digestion in *Cardium edule*, Mr. G. Owen, of this Department, noticed structures, which he termed 'spicules', occurring in the epithelia of the ducts of the digestive diverticula, stomach and midgut. I believe these 'spicules' to be a stage in the life-cycle of a coccidiomorph sporozoan, but can find no account of them in the literature. The following description of them is offered in the hope that if they have already been described I will receive notice of it.

The 'spicules' are slender cylindrical structures about 1·5μ in diameter, tapering quite sharply at one end (the proximal end) and more slowly at the other. They range in length from 10μ to 50μ and are found intracellularly, with the long axis perpendicular to the plane of the epithelium (Fig. 1).

The nuclear region (so designated on the strength of Feulgen-positive staining) is situated about one-fifth of the overall length from the proximal end, that is, the end in the basal region of the epithelium. The apparent structure of this region varies somewhat, depending on both the state of development of the 'spicule' and the staining method used. In any event it seems to consist of a capsule 2–7μ in length containing a Feulgen-positive particle or particles 1–4μ in length. The 'spicule' is a little swollen in this region.

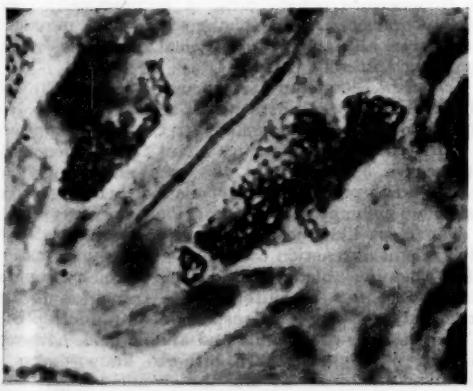

Fig. 1. A 'spicule' and two schizogonic masses in epithelial cells of a duct of *Cardium*. × 2,500

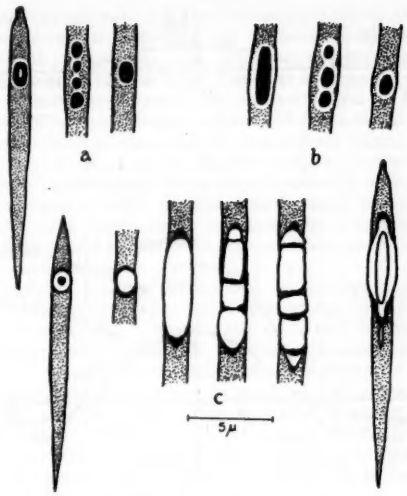

Fig. 2. Appearance of nuclear region produced by (*a*) iron hæmatoxylin; (*b*) Feulgen; (*c*) crystal violet

Epithelia in the ducts of the digestive diverticula contain many schizogonic masses, in highly hypertrophied cells, besides the 'spicule' stage. These schizogonies make the interpretation of feeding experiments very difficult unless the material fed is quite characteristically distinct from them in staining properties. Still other stages can be seen in the connective tissues and amœbocytes between the ducts.

Practically 100 per cent incidence of infection has been recorded in specimens of *C. edule* from Plymouth, Bangor and Millport. The infection is frequently so heavy that it obliterates much of the epithelium.

A full and complete description of the organism will be published later.

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Glacial Shore-lines

The transition of the shore-line in the neighbourhood of a large ice sheet has been calculated on the assumption that the Earth behaved under the load as an elastic spherical shell enclosing incompressible fluid. The analysis is an extension of that of Niskanen[1], who considered uniformly thick and terraced ice caps, but who calculated the shore-line movement only at the centre, at the edge, and 90° from the centre of these caps.

In the present calculations, the ice load was taken to be that of two polar caps the thickness of which is given by

$$h = h_0 \left(\frac{P_2(\cos\theta) - P_2(\cos\theta_0)}{1 - P_2(\cos\theta_0)} \right)$$

where h_0 is maximum thickness of either cap; θ_0 is angular radius of either cap; θ is latitude of any point on the sphere measured from the North Pole; P_2 is a Legendre polynomial of order two.

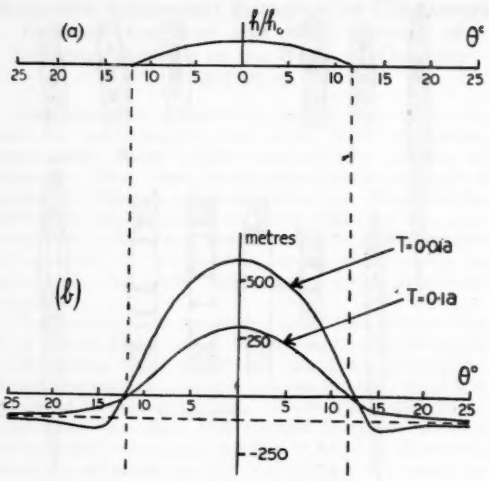

Fig. 1

Fig. 1*a* shows the shape of the northern cap when $\theta = 12°$.

In order to simplify the problem further, it was assumed (following Niskanen) that where there is no ice there is ocean, and that there occurs in this oceanic region a general or eustatic lowering of the sea corresponding to the abstraction of water to form the ice caps. This removal of water from the ocean affects the elastic solution only very slightly, so that in the final calculation of the shore-line movement one may insert any reasonable value of the eustatic lowering without vitiating the elastic solution. In the present case, the volume of ice in two polar caps of maximum thickness 2,500 m. and of angular radius 12° actually corresponds to a eustatic lowering of only 50 m. over the remaining portion of the Earth's surface.

The transition of the shore-line at any point in the oceanic region was obtained by adding algebraically the four quantities: U (radial elastic displacement of the originally spherical surface of the Earth), ζ_1 (radial displacement of the geoid produced by the elastic displacement U), ζ_2 (radial displacement of the geoid produced by the gravitational attraction of the ice cap) and d (eustatic lowering of sea-level). The effect of the mutual attraction of the rearranged water was negligible. A correction to ζ_1 was made to account for the effect of compressibility of the elastic crust.

The rigidity of the crust was taken to be 3×10^{11} dynes per sq. cm., the density to be 3·3 gm. per c.c. and the density of the fluid interior to be 4 gm. per c.c. The transition of the shore-line was calculated for the two cases $T = 0{\cdot}1a$ and $T = 0{\cdot}01a$, where T is the thickness of the elastic shell and a is the mean radius of the Earth. In both cases the eustatic lowering accompanying the glaciation was assumed to be 100 m.; Fig. 1*b* shows the present position of the former glacial shore-line in the northern hemisphere. The glaciated region was not, of course, affected by the eustatic lowering; but if the sea had had access to that area, the present position of the shore would be that shown in the diagram.

It can be seen that, in the area over which there was no ice, there ought now to be raised beaches very near the edge of the former ice cap; but that, farther off, the glacial shore-lines should now be submerged. For the case $T = 0{\cdot}01a$, the present depth of these shore-lines increases rather rapidly with increasing θ (in the northern hemisphere), until it reaches a maximum at about 300 km. from the edge of the cap. Thereafter, the depth decreases and approaches the eustatic limit (100 m.) from below and is nearest to that depth on the equator. For $T = 0{\cdot}1a$, the maximum depth of the shore-line is displaced to $\theta = 30°$ approximately. It is clear, however, that beyond $\theta = 45°$ the departures of the transition from the eustatic limit in either case will be small, and that measurements of the depth of submerged glacial shore-lines made in middle latitudes so to speak will give d fairly accurately. But over a considerable area in the neighbourhood of a former ice cap, the present depth of glacial shore-lines may differ appreciably from that calculated by assuming sea-level changes there to have been wholly eustatic.

Applying these results to south-west England, for example, and to Devon in particular, which lay about 1,600 km. from the centre of the Scandinavian ice cap, we find that the present depth below sea-level of the glacial shore-line should be either 137 m. ($T = 0{\cdot}01a$) or 56 m. ($T = 0{\cdot}1a$), both nearly 40 per cent different from the value of the eustatic lowering.

This work was carried out while I was a research student in the Department of Geodesy and Geophysics, University of Cambridge, and I am indebted to Dr. R. Stoneley for much helpful criticism.

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Slow Disappearance of Fluorescence in Thionine on Addition of Abietic Acid

The quenching of fluorescence in solution by added substances is generally regarded as an almost instantaneous process[1]. We have observed that a quenching process takes a considerable time for completion, affording thereby an opportunity of a very detailed study of the process. If an alcoholic solution of abietic acid be added to a solution of thionine in the same solvent, a slow and continuous decrease of fluorescence occurs until it is practically completely quenched. The change has been measured fluorimetrically, and a few typical results are represented graphically in Fig. 1.

It can be seen from Fig. 1 (curves 1, 2 and 3) that the higher the concentration of the acid or the dye, the more rapid is the quenching. Curve 4 shows that a higher temperature brings about faster quenching, and curve 5 shows that the medium strongly influences the process, *n*-butyl alcohol bringing about faster quenching than ethyl alcohol.

The most likely explanation seems to be that a slow chemical reaction takes place with the formation of a thionine–abietic acid complex which provides little scope for any intermediate transition to the metastable energy-level responsible for fluorescence. The structures of thionine and abietic acid, however, do not readily suggest a hitherto known type of chemical combination. But the chemical interaction, if there be any, must be a very pronounced one, since the equilibrium mixture eventually obtained

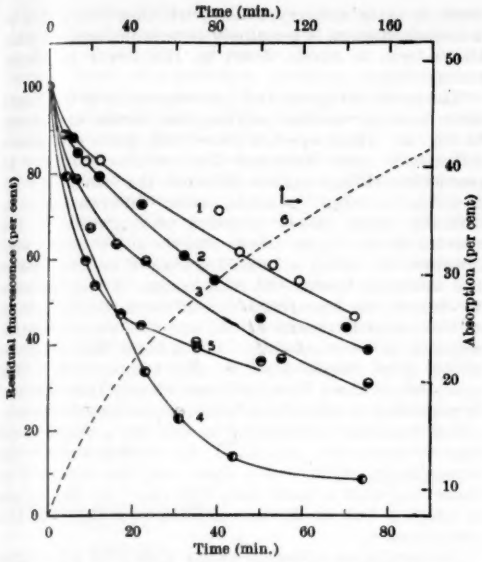

Fig. 1. Change in fluorescence of thionine with time in the presence of abietic acid

Curve No.	Concentration of thionine (*M*)	Con. of abietic acid (*M*)	Temp.	Solvent.
1	10^{-5}	10^{-3}	25° C.	Ethyl alcohol
2	10^{-4}	$0{\cdot}25\times10^{-3}$	25° C.	Ethyl alcohol
3	10^{-4}	10^{-3}	25° C.	Ethyl alcohol
4	10^{-4}	10^{-2}	35° C.	Ethyl alcohol
5	10^{-4}	10^{-3}	25° C.	*n*-Butyl alcohol
6	Change of absorption coefficient with time, under the same conditions as curve 3 (λ = 635 mμ)			

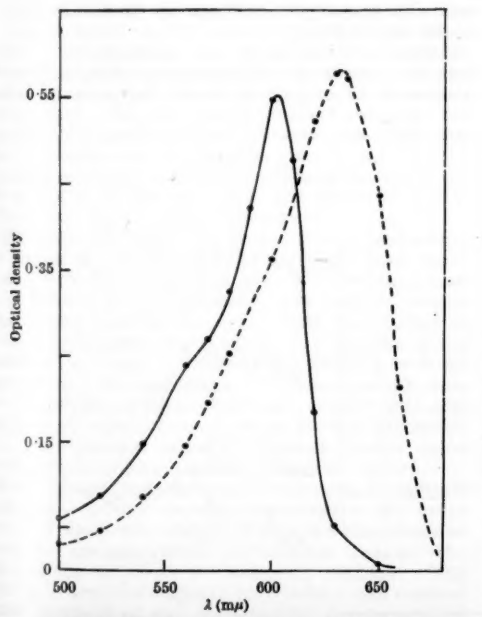

Fig. 2. Change in the absorption spectra of thionine due to quenching by abietic acid. ———, thionine (10^{-5} *M*), max. at 602 mμ; – – – –, quenched thionine, max. at 631 mμ

contains practically no free thionine. On a rough computation, the energy of activation is about 15,000 cal. Moreover, the interaction seems to be highly specific, as a large number of organic substances have been tested by us and found to have no such effect on thionine. Even dihydroabietic acid (differing from abietic acid in one double bond) and its lactone do not quench the fluorescence of thionine. The last observation gives significance to the particular double bond in the abietic acid molecule. Unsaturation, however, is by itself not a factor for quenching, as oleic acid and styrene have been found to be ineffective.

Absorption spectra of thionine in alcohol (Fig. 2) show that, concomitant with quenching by abietic acid, there is also a small shift of about 30 mμ of the absorption maximum towards longer wavelengths. As a result of this shift, absorption is also markedly higher near the new peak, and it is possible to follow the kinetics by measurement of absorption in this region. A typical case of change of absorption with time observed at 635 mμ, which goes parallel with the quenching process, is shown as a dotted curve in Fig. 1 (curve 6).

The above observations thus provide us with a method of studying precisely the kinetics of an addition reaction at extreme dilutions (10^{-4}–10^{-6} *M* or less), and this may have some importance in connexion with biochemical studies involving thionine and similar compounds which are known to affect tissue oxidation and other physiological processes strongly[2]. Also the striking selectivity of abietic acid as described here may be made the basis of a method of its estimation. Detection and estimation of abietic acid have commercial importance since rosin, containing about 85 per cent abietic acid, is very often used as an adulterant to costlier gums such as shellac.

Further investigation is in progress, and detailed results will be published elsewhere.

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Micro-determination of Phosphorus

The increasing application of chromatography to the separation of phospholipids[1] has emphasized the need for greater sensitivity in the estimation of total phosphorus.

Sensitive methods have been described for inorganic phosphate, for example in serum[2], using small volumes of reagents; but they are not readily applicable to the perchloric acid digests obtained in the total phosphorus method, where the volume of acid cannot easily be reduced to less than 2 ml. The method of Allen[3] has proved satisfactory for routine use, but the transference of the digest to a standard flask for development of the molybdenum blue colour results in a final volume of 25 ml. of solution for measurement. The procedure described by Allen for inorganic phosphate in turbid or coloured solutions utilized extraction of the blue compound with *iso*butyl alcohol,

and this principle can be used for simplifying the method for total phosphorus and for increasing its sensitivity about tenfold.

Following digestion with perchloric acid, the colour is developed in the digestion flask as described by Allen and, after 5 min., 3 ml. methyl*iso*butyl ketone is added and the flask shaken for 1 min. To facilitate removal of the coloured ketone layer by pipette, the contents of the flask are poured into a ½-in. diameter test-tube, or the interface is brought into the neck of the digestion flask by adding water saturated with the ketone. The blue colour tends to fade slightly during the first thirty minutes after extraction, but then remains constant for at least one hour and is read during this period.

The calibration curve is linear and passes through zero; 10 μgm. phosphorus gives an extinction of 0·57 at 680 mμ in a 1-cm. cell. As described above, as little as 1 μgm. phosphorus can be estimated; by taking less of the extracting solvent and using micro-cuvettes, the limit could be lowered.

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Infra-Red Spectra and the Polymorphism of Glycerides

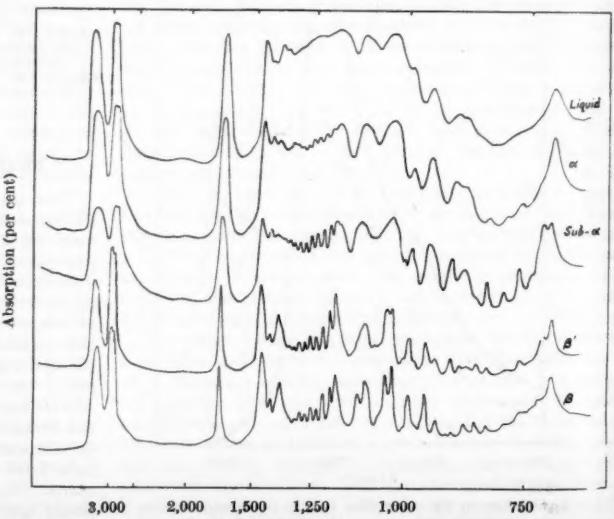
Although it is known that abrupt changes can occur in the infra-red spectra of the crystalline phase when polymorphic transitions occur[1], comparatively little use has been made of this fact to investigate polymorphic changes themselves. The purpose of this communication is to point out that the use of the infra-red technique can be extremely valuable in such cases. The speed of obtaining a spectrum can be useful in those cases where transitions are fairly rapid. Furthermore, information about the molecular structures, for example, hydrogen bonding, etc., can be obtained, and in some cases perhaps even the site symmetry of the molecules in the various polymorphic forms can be deduced.

The polymorphism of some 1-monoglycerides has been investigated using this technique. These glycerides are thought to exist in at least three different forms[2,3], namely, a low melting α-form (vertical rotating chains), two higher-melting forms β′- and β- (inclined chains, alternating melting points). Lutton and Jackson[3] state that the α-form is reasonably stable down to a lower transition temperature, at which point it changes into a new crystalline modification, sub-α, giving a distinctive set of short spacings. Controversy exists over whether the sub-α form is, or is not, crystalline, whether the sub-α to α-transformation is genuinely reversible, and whether the α-form is stable down to the lower transition temperature.

The infra-red spectra of 1-monostearin in the liquid state and in various polymorphic forms are shown in Fig. 1. These spectra show that quite distinctive differences exist between the various forms. In particular, differentiation between the sub-α and the β′-forms is easy, whereas clear differentiation is difficult using X-ray powder photographs. The spectra of the liquid, the α- and the sub-α forms were obtained by using a heated infra-red cell *in situ* in the infra-red beam. By this means it was possible to observe the transformation of the α- to sub-α form at the transition point 47° C., and the transformation appears to be reversible. The α-form was observed to be quite stable down to this temperature. The spectrum of the α-form indicates clearly that rotation is occurring in this phase, while considerable orientational freedom is indicated in the sub-α form in the high-temperature regions. An indication of the crystallinity of the sub-α form may be obtained by observing that a band near 720 cm.$^{-1}$ in the α-form is single; but in the sub-α form it splits into two components.

An analogous situation exists with solid *n*-paraffins in this region of the spectrum. In the liquid state, a single band is observed, near 720 cm.$^{-1}$; this band increases in intensity at the solidification point, and at a lower transition point two components occur[4]. Between the solidification and transition points, the paraffin exists in a hexagonal form, and rotation of the hydrocarbon chains about their axes takes place, whereas below the transition point the crystal system becomes orthorhombic. It can also be compared with the spectrum of polythene, where a band at 725 cm.$^{-1}$ is single in the amorphous or liquid state, but double in the crystalline form. The doubling here occurs because of coupling between the two molecules in the unit cell.

Crowe and Smyth, in an investigation of the dielectric behaviour of 1-monoglycerides[5], suggested orientation of various molecular segments in order



Infra-red spectra of polymorphic forms of 1-monostearin

to explain the wide distribution of relaxation times observed in the sub-α phase despite the order observed by X-ray methods. However, even in the orthorhombic form of *n*-paraffins, rotation of the hydrocarbon chains can occur, perhaps even 30 per cent at room temperature. This could also occur with the hydrocarbon chains of the sub-α form, and would be consistent with the sub-α spectrum. The sub-α form was found to be quite stable at room temperature, in agreement with the observation of Lutton and Jackson[3]. The β- and β′-forms were obtained from solvent by slow and rapid crystallization respectively from light petroleum. X-ray and melting point data were used to confirm the identity of the forms. The spectra of the β′- and β-forms were obtained by dispersing the material in 'Nujol'. In the lower monoglycerides, for example, monolaurin, the transformation from the α-form to the final stable β-form was followed by means of the spectra.

Other glycerides (di- and tri-) have been investigated in a similar manner and detailed results will be published elsewhere.

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Strain in 6,8-Thioctic Acid

In 1952 Calvin[1] advanced the hypothesis that the available energy of the excited chlorophyll molecule starts photosynthesis by splitting the disulphide bond of thioctic acid into the biradical. As the available energy of the chlorophyll molecule is only 35–40 kcal. and the disulphide bond-energy lies somewhere between 60 and 70 kcal. per mole, this process would not be possible were it not for the presence of strain in the 1,2-dithiolane moiety of the thioctic acid molecule. Thus the strain in a 1,2-dithiolane ring becomes important.

Recently, Barltrop, Hayes and Calvin[2] calculated the strain of 1,2-dithiolane in three different ways. A study of the ultra-violet spectra of straight-chain disulphides and 1,2-dithiolanes was used to deduce a maximum value of the strain of 27 kcal. mole^{-1} in the five-membered ring system. An analysis of the probable structure of dithiolane combined with an estimation of the magnitude of different strain factors led to a minimum value of 11 kcal. Finally, a kinetic study of the equilibrium between benzyl mercaptan and 1,2-dithiolane indicated a much smaller value of the strain energy, namely, 6·5 kcal. mole^{-1}.

From general considerations it seems to be difficult to reach a definite decision between the two lower values of the strain energy. The high value obtained from the spectra should be rejected, because the assumptions involved are not very realistic. The structural analysis ought to be reliable; the method is well established and the potential barrier against free rotation around the S—S bond seems to be fairly well known. The accuracy of the equilibrium investigation may suffer from the fact that the reaction studied is not very well defined.

The most direct way to get information on the energy of the 1,2-dithiolane ring system relative to that of a normal straight-chain disulphide is the calorimetric experiment. We have therefore studied the heat of oxidation of a number of thiols to disulphides, using iodine in 90 per cent ethanol as oxidant. The thiols were used in 20 per cent excess, thus assuring quantitative reduction of the iodine. They were of high purity (better than 99·5 per cent) with one exception, the 6,8-dimercapto-octanoic acid (a gift from Dr. I. C. Gunsalus, University of Illinois), which showed 87 per cent purity—as judged from iodine titrations.

The reaction products were analysed spectrophotometrically. Full agreement with Calvin's results on the 1,2-dithia*cyclo*-pentane and -hexane was achieved, showing that monomer ring disulphides were the only identifiable products.

The heat equivalent of the calorimetric system was determined electrically and the reproducibility of the measurements was better than 0·5 per cent.

The actual reaction, for which the heat of oxidation was measured, was

$$2\ R.SH\ (\text{liq.}) + I_2\ (50\ \text{ml. } 0{\cdot}1\ N\ \text{sol. in 90 per cent ethanol, 10 per cent water}) \rightarrow RSSR\ (\text{sol.}) + 2\ HI\ (0{\cdot}1\ N\ \text{sol.}) - \Delta Hr.$$

The following table gives the results in kcal. mole^{-1}.

Thiol	Disulphide	$-\Delta Hr$ (kcal. mole^{-1})
1-Propanethiol	4,5-Dithiaoctane	29·85
1-Pentanethiol	6,7-Dithiadodecane	29·85
1,4-Butanedithiol	1,2-Dithia*cyclo*hexane	29·45
1,3-Propanedithiol	1,2-Dithia*cyclo*pentane	25·75
6,8-Dimercapto-octanoic acid	Thioctic acid	26·20

Taking the heat of oxidation of *n*-propyl and *n*-amyl mercaptans as 'standard' (representing by definition the formation of strainless reaction products), we conclude that under prevailing conditions: (1) the strain in 1,2-dithiolane (parent ring structure) is 4 kcal.; (2) the strain of the substituted 6,8-thioctic acid is about 0·5 kcal. less—in agreement with the fact that substituents stabilize a strained-ring structure; (3) the strain in the six-membered ring 1,2-dithia*cyclo*hexane is on the borderline of significance and probably about 0·5 kcal. mole^{-1}.

The small strain in the coplanar—or almost coplanar—1,2-dithiolane structure is difficult to explain from the results of the strain analysis. However, it should be remembered that the strain analysis is valid for gaseous molecules, assuming zero intermolecular interaction. The calorimetric experiments have been carried out in a condensed phase and the conditions for intermolecular interactions may be significantly different for a normal disulphide with a dihedral angle of about 100° and a 1,2-dithiolane ring with the dihedral angle equal to or near zero.

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Autoxidation of Catechin

A MECHANISM is proposed for the autoxidation of catechin to a polymer (catechin tannin) which has for a long time been recognized to have tanning properties.

Empirical study of the fate of catechin at 100° has revealed two interesting reaction processes. In agreement with Freudenberg's interpretation[1] of phlobaphene formation, at pH < 2, a buff-coloured phlobaphene, which gave the colour reactions of catechol and phloroglucinol, was rapidly formed both in the presence and absence of oxygen. Between pH 4 and pH 8, however, catechin is autoxidized to red catechin tannin. Autoxidation was arrested by sodium hydrogen sulphite, and only epimerization occurred in absence of oxygen. Catechin tannin had phenolic properties, but it lacked the characteristic properties of catechol and phloroglucinol. Under more alkaline conditions another reaction, possibly ring-fission[2] leading to humic acids, intervened.

Catechin in phosphate buffer (pH 8) was shaken at 35° to constant oxygen uptake; when no catechin could be detected in the paper chromatogram of the reaction mixture, the polymer formed was absorbed on alumina and the hydrogen peroxide in the eluate estimated. The results were: total oxygen uptake 1·59, hydrogen peroxide formed 0·38; oxygen balance, 1·4 moles/mole catechin. Oxygen absorption was represented by a sigmoid curve; but as the rate was slow, namely, 0·0006 mole oxygen/mole catechin/min., an induction period was not detected.

When the autoxidation of catechin in phosphate buffer was followed spectrophotometrically, no intermediate was detected, and the resulting catechin tannin had $\lambda_{max.}$ 400 mμ (pH 6) and $\lambda_{max.}$ 420–430 mμ (pH 8). Silver oxide oxidation of dioxan solutions of catechin and catechol gave compounds of $\lambda_{max.}$ 370 mμ (o-benzoquinone ($C_6H_4O_2$) $\lambda_{max.}$ 370 mμ). Catechin tannin was formed when a solution of the corresponding o-quinone was shaken with oxygen in phosphate buffer, and by silver oxide oxidation of catechin in phosphate buffer.

It is now suggested that the main reaction sequence involves formation of o-quinone followed by oxidative condensation. Formation of o-quinone probably involves a free radical mechanism, since the reaction takes place in non-polar solvent. Hydrogen peroxide is associated with quinone formation, and its accumulation results from the difference in velocity of the radical processes, conveniently summarized as:

$$H_2Q + O_2 = Q + H_2O_2; \quad H_2Q + H_2O_2 = Q + 2H_2O$$

The autoxidation of polycyclic hydroquinones has afforded unpublished results (D. E. H.), which confirm formation of hydrogen peroxide in oxidations leading to quinones. Autoxidation of catechin is slow, since the oxidation to quinone is inhibited by phenols[3]. Previous evidence[4] for intermediate formation of o-quinone includes an attempted isolation of a dianilino-derivative (no analysis or melting point) when tea oxidase acts on catechin. The oxidative condensation is an ionic process requiring dissociating medium, in which addition of phenol to quinone occurs, with CC bond formation between one of the electrophilically activated sites (2′,5′,6′) of the quinone and one of the nucleophilically activated sites (6,8) of another quinone molecule or with the (6,8,2′,5′,6′) sites of a catechin molecule. Addition of phenol to quinone involves transfer of two hydrogen atoms to afford diphenylol, followed by oxidation to the corresponding quinone by means of oxygen, hydrogen peroxide or another molecule of quinone. The oxygen balance agrees with this reaction sequence, which permits the formation of a highly irregular three-dimensional polymer, although certain CC bonds are excluded on steric considerations. It is significant that since catechol is not bifunctional, it does not undergo a similar polymerization. A number of catechin derivatives are now being synthesized as model substances with which to test these general conclusions. This reaction sequence has also been postulated to explain the formation of melanin[5] and purpurogallin[6]. It is relevant to a suggestion[7] for the formation of condensed tannins in Nature. By the action of an oxidase on catechin there results o-quinone, which is normally reduced by an oxygen acceptor, for example ascorbic acid; but enzymic oxidation of o-quinone to catechin tannin occurs whenever the reduction mechanism is intercepted. This explanation is similar to that proposed[8] for the action of tyrosinase on tyrosine, and the action of plant polyphenolases on catechin is being investigated.

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Occurrence of Different Beta-Lactoglobulins in Cow's Milk

DURING the past twenty years, numerous physicochemical investigations of crystalline β-lactoglobulin prepared from cow's milk have revealed a degree of heterogeneity puzzling in a protein considered to be 'pure' (see the recent discussion of this problem by Ogston and Tilley[1]). In general, mixed milk has been used as the starting material, and it has been tacitly assumed that the β-lactoglobulin synthesized by the mammary gland is the same for all cows. This is not the case.

When a suitably prepared fraction of the milk of single cows (for example, the proteins soluble in 20 per cent sodium sulphate) was subjected to electrophoresis on filter-paper in barbitone buffer at pH 8·6, I = 0·05, using an apparatus of the type described by Flynn and de Mayo[2], and applying 230 V. for 16 hr., we found that individual cows produce either a mixture of two electrophoretically distinct β-lactoglobulins or only one or the other of these, as shown in Fig. 1, which gives examples of each type. The two single components will be termed β_1- and β_2-lactoglobulin, following the nomenclature suggested by Polis, Shmukler, Custer and McMeekin[3], and the mixture of the two in the milk of an individual cow

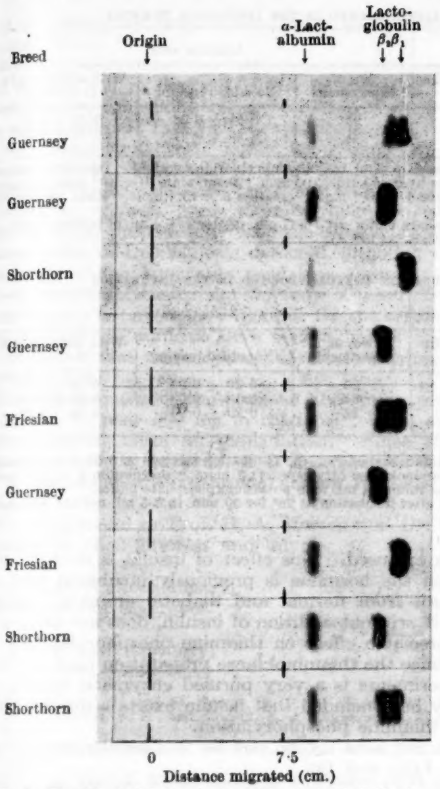

Fig. 1. The β-lactoglobulins in the milk of nine individual cows (bromo-phenol blue staining)

will be termed $\beta_{1,2}$-lactoglobulin. In most instances, the mixture contains more β_1- than β_2-lactoglobulin.

So far as can be ascertained from our limited electrophoretic data for the milk of the same animal examined on different occasions during one, two or three lactation periods, the type of β-lactoglobulin produced is characteristic for a given cow. Up to the present, 27 Shorthorn, 22 Friesian, 12 Ayrshire and 9 Guernsey cows belonging to the Institute herds have been typed: 30 were found to produce $\beta_{1,2}$-, 7 β_1- and 33 β_2-lactoglobulin. The $\beta_{1,2}$- and β_2-forms were found with all four breeds, but the β_1-lactoglobulin as yet only in the milk of Shorthorn (3) and Friesian (4) cows. We have also examined the milk of eight sets of one-egg twin heifers. In each set the two animals produced the same type of protein, four sets giving $\beta_{1,2}$-, two β_1- and two β_2-lactoglobulin. It thus appears that the synthesis of these β-lactoglobulins is genetically determined; but much further work is clearly required on possible breed or breeding differences.

Starting from appropriately selected milks, β_1- and β_2-lactoglobulins have been prepared in the crystalline state for investigation of their physico-chemical properties. The crystals were found to be distinctly different; β_1-lactoglobulin forms rectangular plates indistinguishable from the well-known crystals hitherto prepared from mixed milk, and first photographed by Palmer[4], whereas β_2-lactoglobulin forms diamond-shaped plates, as illustrated in Fig. 2. The β_1-component may be identical with the fraction isolated in small yield from the β-lactoglobulin of mixed milk by Polis *et al.* Preliminary results point to other measurable differences between the β_1- and β_2-forms, for example, in the isoelectric point and solubility.

Further work on the properties of the isolated β-lactoglobulins and on the occurrence of the various forms in the milk of individual cows, with special reference to twins and to dams and their daughters, is now proceeding.

We are grateful to Mr. N. Gruber for the photographs.

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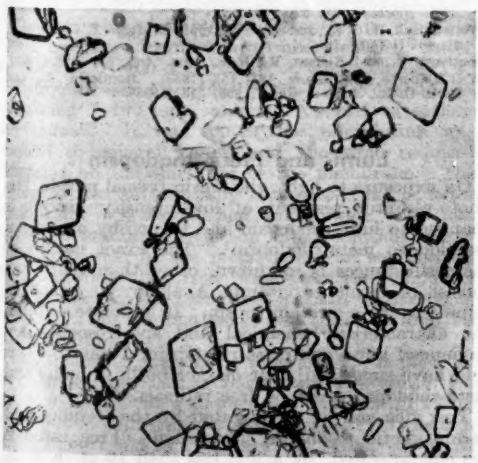

Fig. 2. Crystals of β_1-lactoglobulin. (× *c.* 100)

Action of Insulin on Thiamine Phosphorylation *In vitro*

Previous work has demonstrated that in pancreatic diabetes a disturbance of the thiamine phosphorylation processes occurs and that the administration of insulin enhances the phosphorylation of thiamine provided that a sufficient amount of this substance is available to the organism[1].

It is known that insulin increases the synthesis of adenosine triphosphate and of phosphocreatine in muscle[2] and in liver[3], and thus directly or indirectly influences all phosphorylation reactions connected with adenosine triphosphate or phosphocreatine.

In order to show a direct action of insulin on the enzyme system phosphorylating thiamine, Foa *et al.*[4] studied the effect of insulin *in vitro* by adding this hormone, together with thiamine, to liver homogenates from normal and diabetic rats and then determining the formation of thiamine phosphates. Addition of insulin to homogenates from alloxan diabetic rats enhanced the phosphorylation of thiamine, thus lending weight to the hypothesis that insulin acts directly on thiamine phosphorylation.

Table 1. Amount of Cocarboxylase (μgm./gm. Fresh Liver) formed in the Incubation Mixture

Incubation	Normal rats			Diabetic rats		
	No. of experiments	No added insulin	With added insulin (1·2 units)	No. of experiments	No added insulin	With added insulin (1·2 units)
A	24	0·68 ± 0·10	0·72 ± 0·11	23	0·54 ± 0·08	0·57 ± 0·11
B	20	0·61 ± 0·11	0·59 ± 0·10	21	0·46 ± 0·07	0·47 ± 0·09

(*A*) Liver homogenate in isotonic potassium chloride solution (1 gm. of tissue + 3 ml. of potassium chloride solution). Incubation mixture contains: liver homogenate corresponding to 200 mgm. of fresh liver; thiamine hydrochloride, 100 μgm.; magnesium 2×10^{-3} mole; glutamic acid 0·2 m.mole; cytochrome *c* 3×10^{-5} mole; sodium adenosine triphosphate 5×10^{-4} mole; creatine 5×10^{-4} mole. Made up to a final volume of 4 ml. with potassium chloride solution. Incubation at 38° for 40 min.

(*B*) Liver homogenate in isotonic potassium chloride – potassium phosphate buffer *p*H 7·5 (1 gm. of tissue + 4 ml. of isotonic solution); the suspension dialysed for 2 hr. against the same buffer. Incubation conditions as in (*A*).

Table 2. Amount of Cocarboxylase (μgm./3 ml. of Incubation Mixture) formed in the Incubation

Incubation	Normal rats			Diabetic rats		
	No. of experiments	No added insulin	With added insulin (0·7 unit)	No. of experiments	No added insulin	With added insulin (0·7 unit)
A	18	0·26 ± 0·04	0·27 ± 0·05	20	0·20 ± 0·03	0·19 ± 0·03
B	20	0·24 ± 0·03	0·28 ± 0·06	21	0·19 ± 0·03	0·36 ± 0·04
C	20	0·31 ± 0·05	0·36 ± 0·06	22	0·20 ± 0·03	0·34 ± 0·05

Results are means ± the standard error of the means.

(*A*), (*B*), (*C*): Liver thiaminokinase preparations according to Leuthard and Nielsen (ref. 6). Incubation mixture in 0·05 mole potassium phosphate buffer, *p*H 7·4, containing thiamine hydrochloride 50 μgm.; thiaminokinase (dry powder) 3 mgm.; magnesium 2×10^{-3} mole; glutamic acid 0·2 mole; sodium adenosine triphosphate 5×10^{-4} mole. Final volume 4 ml. with potassium phosphate buffer.

Insulin was added to the incubation mixture: in (*A*) directly; in (*B*) after incubation at 38° for 30 min. in 0·5 ml. normal rat serum; in (*C*) after incubation at 38° for 30 min. in 0·5 ml. diabetic rat serum.

We carried out experiments with liver homogenates under conditions very similar to those reported later by Foa *et al.*[4] (Table 1,*A*), and further work was then undertaken adopting the same experimental conditions as stated by these authors (Table 1,*B*). In neither case could their claims be confirmed.

The discrepancy in the results obtained by us and those of Foa *et al.* may be attributed to a different method in estimating the level of thiamine phosphorylation. While in our experiments cocarboxylase, enzymatically determined[5], has been assumed to be the index of thiamine phosphorylation, Foa *et al.*[4] analysed the materials by means of the thiochrome method, which determines both thiamine mono- and pyro-phosphate. The crude homogenate represents a very complicated enzymatic system, containing many interfering factors, which cannot always be estimated. Even if thiamine phosphorylation were found to be enhanced in such a system, this is not sufficient evidence for a direct action of insulin.

In other experiments, therefore, the action of insulin on thiamine phosphorylation using a much simplified system such as that described by Leuthard and Nielsen[6], which exhibits a strong thiaminokinase action, has been studied. The results of these experiments are reported in Table 2.

The addition of insulin to thiaminokinase preparations from normal and alloxan diabetic livers does not, however, exhibit any positive effects. Thus no significant difference in thiamine phosphorylation between samples with and without the addition of insulin was observed (Table 2,*A*).

Weil-Malherbe and also Bornstein and Park[7] have observed that the presence in blood of factors inhibiting or activating the hexokinase reaction is closely related to the hypophysial and adrenal cortical hormones and also to insulin. Hence further experiments were carried out in which insulin was added to the thiaminokinase preparations after incubation with serum from normal or from diabetic rats (Table 2,*B*,*C*). Little or no effect is observed when insulin, previously incubated in serum, is added to the thiaminokinase preparations from normal rats, whereas cocarboxylase formation is remarkably enhanced when thiaminokinase extracts from diabetic rats are used. This effect of insulin is evident only when the hormone is previously incubated both in serum from normal and diabetic animals. Serum itself, without addition of insulin, does not exert any appreciable effect on thiamine phosphorylation.

Since the thiaminokinase preparation used in these experiments is a very purified enzymatic system, it may be concluded that insulin exerts a direct action on thiamine phosphorylation.

Amorphous insulin powder was kindly supplied by Eli Lilly and Co.

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Lumi- and Meta-Rhodopsin

On exposure to light, rhodopsin (visual purple, the photo-receptor pigment of low-intensity vision) is changed to lumi-rhodopsin and thence by a thermal reaction to meta-rhodopsin[1]. The exact nature of these substances is unknown, other than that they consist of retinene (vitamin A aldehyde) joined in some way to a protein, opsin. In order to explain the characteristic chemical and spectroscopic behaviour of lumi- and meta-rhodopsin, workers in this field have suggested[1] that one, or both, of lumi- and meta-rhodopsin may be free radicals.

This idea can be investigated by the technique of paramagnetic resonance absorption. Free radicals are characterized[2] by a line less than 10 gauss wide with a *g*-factor differing from 2·0023, the free

electron value, by only a few parts in the third decimal place.

Rod outer segments from cattle eyes were prepared[3] and freeze-dried in dim red light. 51 mgm. of the dried powder, containing $1 \cdot 4 \times 10^{-7}$ mole of rhodopsin, was examined; first, before exposure to light, that is, containing rhodopsin; again, after exposure to light at 90° K., which converts rhodopsin to lumi-rhodopsin; and finally, after warming to room temperature, to convert lumi- to meta-rhodopsin. In none of these preparations was the resonance line characteristic of free radicals detected, although the sensitivity of the apparatus used was sufficient to detect considerably less than 10^{-7} mole of free radical if the line was as narrow as expected. On the assumption that all free radicals show such a line, it must be concluded that neither lumi- nor meta-rhodopsin is a free radical.

The displacement of the retinene absorption peak at 384 mμ to near 500 mμ in rhodopsin, lumi- and meta-rhodopsin lacks an explanation. Since free radicals cannot be invoked, it is necessary to look for a conventional auxochrome linking retinene to protein.

We are grateful to Prof. R. A. Morton and Dr. B. Bleaney for their interest and advice.

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X-Ray Emission Spectrography using Ion Exchange Membranes

The spot-test technique of X-ray emission spectrography[1] for microgram amounts of elements has been extended to lower concentrations of metal ions by using ion-exchange resin membranes to concentrate the elements present as ions in dilute solution, and to act as a carrier for the sample in the spectrograph.

The following technique was employed. Pieces of cation exchange membrane ('Amberplex *C*–1' cation membranes, Rohm and Haas Co., Philadelphia, Pa.) 1 cm. square were placed in 100 c.c.–1 litre of solutions containing 1–100 μgm. amounts of various cations and stirred. It was found that equilibrium was reached in several hours, and the time required depended on the thickness of the membrane. The exchange was substantially complete, that is, after equilibrium was established, there were less than detectable amounts of the ion left in solution. Complete extraction of the metal ion from solution by the membrane occurred whenever the exchange capacity far exceeded the total amount of the ion in solution. Thus the method is best suited to analysis at high dilution.

The following example is illustrative. A piece of the 'Amberplex' cation membrane 1·3 cm. × 1·3 cm. × 0·1 cm. in its acid form was stirred with 1 litre of a solution containing 1 μgm. of cobalt (II) ions (a concentration of 1 in 10^9) for 48 hr. Analysis of the membrane in the X-ray spectrometer indicated that it had absorbed by ion exchange 1·0 μgm. of cobalt with an error of ± 0·1 μgm. Similar results were obtained using other ions. It appeared that the rate of equilibration was approximately logarithmic, and the half-time for membranes 0·1 cm. thick was about 2–3 hr. Thinner membranes reached equilibrium faster, had a lower background in the spectrometer, and showed less absorption of the characteristic radiation of the several elements measured.

As an illustration of the applications of this method to trace analysis of heavy metals in foods, 100 c.c. of maple syrup was diluted to 1 litre and extracted with a piece of the 'Amberplex' cation exchange membrane. Approximately 0·5 μgm. each of zinc and manganese and 1 μgm. of iron was extracted by the membrane along with lesser amounts of other ions.

When a piece of the membrane was equilibrated with 100 c.c. of a solution containing 10 μgm. of cobalt, and 10 c.c. of versene solution (tetrasodium salt of ethylene diamine tetra acetic acid), the cobalt was retained in solution by the chelating agent. The same reagent removed zinc but not iron from a membrane containing ions of these metals. It was observed also that the equilibration of membranes in 40 per cent sulphuric acid was very effective in reducing the background of all heavy-metal ions present including iron.

We feel that the ion-membrane technique extends the utility of X-ray emission spectrography into new areas beyond the range of previous methods. It can be easily adapted to analyses for anions and to various other studies such as the determination of stability constants of complex ions in solution.

We thank the Rohm and Haas Company for co-operation in supplying some special thin ion-exchange membranes for this study.

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Radio-Frequency Radiation from the Rosette Nebula

A recent radio survey of the galactic anti-centre region, made at 242 Mc./s. with the Ohio State University radio telescope, has revealed an intense extended radio source in the constellation of Monoceros. The co-ordinates of the radio source agree closely with the position of the Rosette nebula surrounding the galactic cluster *NGC*2244. Also the width in right ascension of the radio source is comparable with the diameter of the nebula. Thus, it is presumed that the radio source may be identified with the Rosette nebula.

The antenna of the Ohio State telescope has a half-power beam width of 1·3° in right ascension and of 8° in declination. The right ascension of a source is determined by the time at which the maximum intensity is received, while the declination is determined by comparing records taken at several different declinations. The equivalent angular size[1] of a source is obtained by comparing the beam-width of the source signature with the beam-width for a point source.

The position and angular size of the radio source and of the nebula are compared in Table 1. The total intensity from the nebula is about 2×10^{-24} w. m.$^{-2}$ (c./s.)$^{-1}$ (± 25 per cent).

Table 1. (1950·0)

	R.A.	Declination	Angular diameter
Radio source	06h. 30·3m. ± 0·5m.	+ 5° ± 1°	1·5° ± 0·5°
Rosette nebula (*NGC*2244)	06h. 30·0m.	+ 4° 54′	1·33°

In studies of the Rosette nebula with the 48-inch Schmidt telescope, Minkowski[2] found a fairly symmetrical sharp-edged disk of emission 80′ in diameter around the galactic cluster *NGC*2244. He indicated that the luminosity of the nebula is due to the ultraviolet radiation of four *O*-type stars in the central cluster. According to new data[3], he indicates that the average electron density is about 14 cm.$^{-3}$.

Our radio observations show an apparent blackbody temperature over the nebula of approximately 200° K. Assuming an electron temperature of 10,000° K. in the nebula, the average optical thickness at 242 Mc./s. over this region is then 0·02. According to the analysis of Greenstein and Minkowski[4], this corresponds to an emission measure of 3,000, assuming thermal emission by free-free transitions. Considering that the nebula is a Strömgren sphere at a distance of 1,400 parsecs, with a corresponding linear diameter of 37 parsecs, this leads to an average electron density in the nebula of 9 cm.$^{-3}$.

A sketch of the outline of the Rosette nebula in relation to the position of the radio source is presented in Fig. 1. A signature of the radio source taken on February 18, 1955, with the antenna beam directed to Dec. + 6° is also shown.

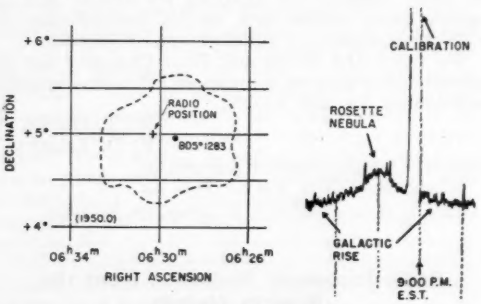

Fig. 1. Outline of the Rosette nebula (dashed line) compared with the radio position (cross); and signature of the Rosette nebula as obtained on February 18, 1955, with the Ohio State University radio telescope

During the survey of the galactic anti-centre region in which radiation was detected from the Rosette nebula, eighteen other intense radio sources were also found. Half of them show angular diameters of 1° or more, and their distribution shows a marked concentration along the galactic plane. A more detailed description of this work will be published separately.

This work has been aided by continuing grants from the Development Fund and the fund for basic research of the Ohio State University, and also by a grant from the National Science Foundation.

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May 4.

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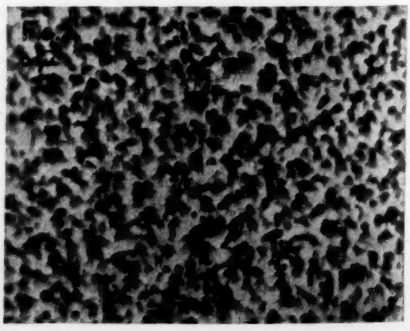
Electron Micrographs from Thick Oxide Layers on Aluminium

The thicker protective coatings of oxide formed on aluminium by anodizing in acid electrolytes have long been of importance in industry. The porous nature of these layers has been indicated by their electrical and adsorptive properties. However, electron microscopic investigation has been almost entirely confined to extremely thin (less than 1μ) oxide layers[1] due to the limitations of the transmission method of examination. By using the recently developed evaporated carbon film technique[2], we have been able to obtain electron micrographs of both the top surface and the cross-section of thick oxide layers. These clearly show the porous structure.

Fig. 1 is a micrograph obtained from the top surface of an oxide layer prepared in 5 per cent chromic acid. The specimen was electropolished 99·99 per cent pure aluminium strip anodized at 40° C., the voltage reaching 90 V. at the end of 100 min. A nitrocellulose-backed 'Formvar' replica was stripped from the surface on scotch tape and a carbon film evaporated on to it. This was shadowed *in situ* with gold-palladium alloy at an angle of approximately 20°, the replica then being mounted on a copper specimen grid and the plastic dissolved away with organic solvents. The shadowed carbon replica thus prepared formed a 'negative' of the original surface, and was examined at a magnification of 12,400. The micrograph has been enlarged to a magnification of 25,000. The features shown are regularly distributed and are those expected from the penetration of the replica into a porous surface. 'Carrot'-shaped projections arising from single pores can be discerned. In places it appears that the replicated pores have merged and their individuality is lost.

Fig. 2 is a micrograph obtained from an oxide cross-section prepared in 17·5 per cent v/v sulphuric acid. The specimen was a strip of electropolished 99·99 per cent pure aluminium anodized at room temperature for 60 min. at a current density of 50 m.amp./cm.^{2}. The anodized strip was mounted in a moulded block with 'Araldite' casting resin *D*. A cross-section normal to the plane of the oxide surface was ground on fine emery papers and finally polished with magnesia on a rotating cloth. The replica was obtained as described above. It was shadowed in the direction of the metal/oxide boundary and examined at a magnification of 10,000. In the micrograph a region at the metal/oxide boundary is shown with the tubular-shaped pores running up to the interface. The parallel alignment of these pores and their orientation normal to the interface is striking. Together with other micrographs obtained,



it appears that the pore structure is only revealed in this way at places where minute fragments have been chipped out of the oxide layer during the preparation of the specimen surface.

This investigation is being continued and forms part of a research programme of the Food Investigation Organization of the Department of Scientific and Industrial Research on the development of the Torry capacity-resistance hygrometer. The work is being carried out to ensure that an instrument of standard characteristics, free from hysteresis and stable over a wide range of operating conditions, will be produced. It is hoped to publish a fuller account of the work elsewhere.

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March 22.

[1] Fischer, H., and Kurz, F., *Korrosion und Metallschutz*, **18**, 42 (1942). Edwards, J. D., and Keller, F., *Trans. Amer. Inst. Min. Met. Eng.*, **156**, 288 (1944). Huber, K., *J. Colloid Sci.*, **3**, 197 (1948). Keller, F., Hunter, M. S., and Robinson, D. L., *J. Electrochem. Soc.*, **100**, 411 (1953).
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Reactivity of Freshly Formed Steel Surfaces

It is now an established fact that freshly formed metal surfaces have an inherently high reactivity. A probable confirmation of this fact was noticed recently when specimens of mild steel were broken by impact at sub-zero temperatures. Fracture was predominantly of the cleavage type at the temperatures concerned, and the work undertaken necessitated an examination of the fracture surface. It was noticed that this surface corroded far more rapidly than would normally be expected in the laboratory atmosphere. Ten minutes after fracture, definite corrosion films could be detected and the well-known rust-coloured deposit appeared shortly afterwards.

Undoubtedly the fracture surface would be covered by a film of adsorbed moisture and, in view of the recent work on the production of hydrogen peroxide on freshly formed metal surfaces[1], it is likely that the oxidation mechanism was associated with hydrogen peroxide formation as suggested by Haber and Weiss :

$$H_2O_2 + Fe^{++} \rightarrow Fe^{+++} + OH^- + OH$$
$$OH + Fe^{++} \rightarrow Fe^{+++} + OH^-$$
$$Fe^{+++} + 3OH^- \rightarrow Fe(OH)_3 .$$

Whatever the corrosion mechanism, the fact remains that freshly cleaved steel surfaces are extremely reactive. The method of cleaving specimens at an appropriate temperature would probably be useful in the investigation of the reactivity of metal surfaces.

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March 22.

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A Method of locating Interfaces in Oil Pipelines

It is often desirable to locate or follow the interface between two oils or fuels during transmission along a pipeline. Present methods include those based upon sampling techniques or radioactive labelling of the interface. The first of these is tedious and slow, and the second method involves the injection of a radioactive marker substance at the interface, with the attendant difficulties of handling radioactive material in the product itself.

An alternative method utilizes the variation of hydrogen content of the two liquids. Hydrogen contents of bulk liquids may be easily compared by the use of a neutron-backscatter or transmission technique. A portable source of fast neutrons can be placed outside the pipe. The neutrons entering the liquid are moderated by scattering from the hydrogen atoms, and the concentration of slow neutrons which emerge from the pipe (either in a forward or backward direction) will be dependent on the hydrogen content of the liquid in the pipe. These can be measured with the use of standard equipment incorporating a boron trifluoride counter.

Preliminary laboratory tests indicate that the measurement of either scattered or absorbed neutrons can differentiate between premium and commercial grade fuels by a 5 per cent change in reading. A further change of 10 per cent occurs between commercial fuel and paraffin.

In the event of the two liquids having the same hydrogen content, if the interface could be labelled with minute quantities of a salt of boron, gadolinium or other suitable material, then it could be located very easily, since these additives absorb the slow neutrons very strongly.

These methods have the great advantage over standard radioactive methods that they do not involve the inconvenience of handling radioactive material in solution, or the necessity of obtaining a regular supply of radioactive isotopes.

The preliminary work carried out on neutron-scattering methods indicates their considerable potentialities, and techniques will be further investigated.

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May 31.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

LECTURER (Grade II) or SENIOR LECTURER (Grade I) IN THEORETICAL PHYSICS—The Registrar, The University, Bristol 8 (August 6).

LECTURER or ASSISTANT LECTURER IN BOTANY—The Registrar, The University, Birmingham 15 (August 6).

ASSISTANT (preferably with a veterinary qualification) IN THE DEPARTMENT OF VETERINARY PHARMACOLOGY—The Secretary, Royal (Dick) School of Veterinary Studies, The University, Edinburgh (August 8).

RESEARCH DEMONSTRATOR IN PURE MATHEMATICS—The Registrar, The University, Sheffield (August 10).

RESEARCH WORKER (with a university degree, preferably in forestry, and some practical forestry and research experience) to undertake a special study of the problem of planting mining refuse heaps in Scotland—The Secretary, The University, Edinburgh (August 15).

SENIOR LECTURER or LECTURER IN BIOCHEMISTRY at University College, Ibadan, Nigeria—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (August 15).

PHYSICIST or MATHEMATICIAN (with a good honours degree in physics, mathematics or equivalent professional qualifications, proved research ability, and preferably experience in strain measurements and/or mechanical properties of materials), at the Central Research Establishment, National Coal Board, Isleworth, to lead a group carrying out research on underground transport of coal—National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting SS/34 (August 16).

BIOCHEMIST (with a Ph.D. degree or equivalent, and preferably with experience in microtechniques) to be a member of a team investigating the growth and metabolism of cells obtained from tumours and from normal organs and grown in culture—The Director, Strangeways Research Laboratory, Wort's Causeway, Cambridge (August 20).

LECTURER IN PSYCHOLOGY—The Registrar, The University, Sheffield (August 20).

ADMINISTRATIVE ASSISTANT (with a scientific degree, preferably in physics, and administrative experience), for work in connexion with the International Geophysical Year—Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (August 30).

LUCAS CHAIR OF ENGINEERING PRODUCTION—The Registrar, The University, Birmingham 15 (August 31).

STAFF TUTOR IN SCIENCE in the Department of Extra-Mural Studies—The Registrar, The University, Nottingham (August 31).

LECTURER IN PHYSICS, and an ASSISTANT LECTURER IN PHYSICS—The Registrar, College of Technology, Manchester 1 (September 1).

LECTURERS (2) IN CHEMICAL ENGINEERING, and DEMONSTRATORS IN CHEMISTRY—The Registrar, College of Technology, Manchester 1 (September 1).

ASSISTANT (with a degree in science or agriculture) IN THE CHEMISTRY DEPARTMENT at Auchincruive, for work mainly relating to the analysis of agricultural materials other than soils—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (September 12).

JUNIOR ORGANIC CHEMIST—(with a first- or second-class honours degree in chemistry and two or three years' research experience in organic chemistry) IN THE DEPARTMENT OF SUGAR CHEMISTRY AND TECHNOLOGY, Imperial College of Tropical Agriculture, Trinidad—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (September 17).

READER IN ZOOLOGY at Royal Holloway College, Englefield Green, Surrey—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 20).

SENIOR LECTURER (preferably with special qualifications in embryology and/or cytology) IN ZOOLOGY at the University of Western Australia—Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

BIOCHEMIST (with an honours degree in chemistry or biochemistry, and with one or two years' biochemical research experience), to assist in research work in the Special Unit for Juvenile Rheumatism—The Secretary, Canadian Red Cross Memorial Hospital, Taplow, near Maidenhead.

BRITISH NYLON SPINNERS LIMITED RESEARCH FELLOW to work on the structure of wool and nylon staple fibre fabrics—The Principal, Technical College, Bradford 7.

ENTOMOLOGISTS (2) (with a degree in zoology and a sound knowledge of entomology and botany), with the Sudan Government, to carry out a survey of the tsetse areas of the Sudan and undertake research work—The Sudan Agent in London, Cleveland Row, St. James's, London, S.W.1, quoting "Entomologist 2204".

LABORATORY TECHNOLOGIST (with a general degree in science or agriculture, with main interest in chemistry, or an honours degree in chemistry) IN THE DEPARTMENT OF AGRICULTURE, Kenya, to carry out investigational work on problems of agricultural chemistry related to coffee culture—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.63/7/09.

PASTURE AGRONOMIST (male, with a university degree in science or agriculture, a special interest in animal husbandry problems and experimental methods used in feeding and grazing trials, and a knowledge of systematic botany to enable ecological surveys to be undertaken) IN THE DEPARTMENT OF VETERINARY SERVICES, Uganda, to conduct feeding and grazing trials, with particular reference to the effect on the animal, and field investigation into the management of grassland systems of grazing and livestock management—Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting BCD.67/9/08.

PHYSICIST (with at least a second-class honours degree) to carry out fundamental research work on the behaviour of textile materials as barriers to (*a*) the flow of fluids, and (*b*) radiation, including heat and light; and a PHYSICIST (or Chemical Engineer) (with at least a second-class honours degree), to conduct research on the drying of textiles, including fundamental work on the mechanism of drying and applied research on the improvement of old methods and the development of new—Dr. F. C. Toy, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

PRINCIPAL SCIENTIFIC OFFICER (with at least a second-class honours degree in physics, mathematics or engineering, or equivalent qualifications) IN THE RESEARCH AND DEVELOPMENT BRANCH of the U.K. Atomic Energy Authority, Risley, to lead a group engaged on the calculation of critical dimensions of plant containing fissile material, and to advise design offices and factories concerning the safety of such plant—Recruitment Officer, Industrial Group Headquarters, Risley, Warrington, Lancs, quoting "1,049".

SCIENTIFIC OFFICER (honours graduate in chemistry or biochemistry) to collaborate in fundamental biochemical research, with special reference to the synthesis and degradation of isotopically labelled compounds and the application of chromatography and other analytical techniques to their isolation and purification—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 55/13.

SENIOR EXPERIMENTAL OFFICER (Electronics) (with at least H.S.C. in science subjects or equivalent qualifications, together with wide experience of the application of electronics) IN THE RESEARCH AND DEVELOPMENT BRANCH of the U.K. Atomic Energy Authority, Windscale, Sellafield, Cumberland, to take charge of a small section engaged on design and construction of various electronic equipment for the chemistry, metallurgy, engineering and physics laboratories—Recruitment Officer, Industrial Group Headquarters, Risley, Warrington, Lancs, quoting "1,048".

SENIOR LECTURER (with an honours degree in mathematics, and preferably with research experience) IN MATHEMATICS—The Principal, West Ham College of Technology, Romford Road, Stratford, London, E.15.

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics, a background of experience in solid-state physics and at least three years' postgraduate research experience), to investigate certain physical aspects of the detonation of solid high explosives and the propagation of intense shock waves through solids and gases—Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting 709/WGE/2.

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